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China Report

SCIENCE AND TECHNOLOGY

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CHINA REPORT

SCIENCE AND TECHNOLOGY

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PEOPLE'S REPUBLIC OF CHINA

NATIONAL DEVELOPMENTS

REFORM OF LOCAL SCIENCE, TECHNOLOGY COMMISSIONS DISCUSSED

Tianjin KEXUEXUE YU KEXUE JISHU GUANLI [SCIENCE OF SCIENCE AND MANAGEMENT OF S&T] in Chinese No 1, Jan 87 p 1

[Article by Xu Runda [1776 3387 6671]: "New Demands in the New Era"]

[Text] Two tides are surging toward us today. One is all-around reform, known as China's second revolution, which will quicken its pace this year. The other is the development of modern S&T, the so-called world high-tech revolution in which new breakthroughs will occur this year. These two tides overlap and propel each other along, like mighty raging rivers.

The development of a socialist commodity economy and the emergence of a series of new disciplines are not ordinary economic progress and technical breakthroughs. They are an all out revolution battering and changing industrial, social, and technical structures, as well as society's outdated traditional ideas, ways of thinking, and working habits. It will revolutionize the face of society and its modes of thought.

To meet the challenge of reform and the high-tech revolution, we on the local science and technology commissions must focus on where economic construction meets science and technology, reform our system as required by the development of the commodity economy and scientific and technical progress, broaden our vision, update our ideas, and work more effectively.

The practice of reform has raised many problems in the work of local science and technology commissions that must be addressed and resolved. For example:

1. Everybody agrees that S&T management should be microeconomic rather than macroeconomic and should rely mainly on indirect management rather than direct management. Then which among the jobs that commissions used to do, such as "reviewing projects, allocating funds, evaluating research achievements, and recommending projects for awards to higher authorities" should be delegated? To whom? What mechanisms should we employ to regulate and control? What services should be provided for the grassroots? Which supervisory and inspection methods should be adopted?

2. The top priority of scientific and technical work is to expedite technical transformation and technical progress as they relate to the national economy. At present China's industry, agriculture, and township and town enterprises all lack the ability to absorb, assimilate, and develop new technology. They

are also short of scientific, technical, and managerial personnel. What can S&T commissions do to effectively strengthen their cooperation with planning, economic, agricultural, and educational agencies, with the science associations, and with personnel departments, in the interest of comprehensive planning and coordination? If science and technology are to play a role in urban construction and the building of the spiritual civilization, what should be the relations and effective forms of coordination between S&T commissions, on the one hand, and departments in charge of urban construction, environmental protection, resources, population, and culture, on the other?

3. Turning to the reform of the scientific and technical system, this year we must push for horizontal association between scientific research organizations and enterprises. This will be a powerful measure to help realize the policy--"making industry depend on science and technology, orienting science and technology toward industry." We must now review experience and take additional coordinated steps to create a favorable environment and make science and technology and industry more appealing to each other.

In implementing the director responsibility system, how should we divide the work between the administration, the CPC committee, and the worker representative assembly? How should we decide the details relating to the director's responsibilities and powers, the substance and methods of party committee supervision, and the format and institution of democratic management, among others?

Reform requires the formulation of a series of policies and measures, which, in turn, necessitates joint studies between the proper departments in charge and agencies responsible for fiscal matters, taxes, finance, and personnel. How can their work be coordinated? What should be their working methods?

4. The development of a commodity economy requires us to develop correspondingly a market consciousness, a sense of competition and efficiency, and a sensitivity to information. The development of modern science provides us with a scientific way of thinking and demands that we observe and study objects comprehensively, coherently, and systematically and that we take realities as our point of departure and, from the viewpoint of development, think exploratively and creatively. In what ways should science and technology commissions themselves go about studying and researching? What should they do to disseminate, popularize, and universalize effectively?

5. What would be a good way to organize and run the local S&T commissions? How should their work be evaluated? What should be the tenure of office of commission leaders? What should be the qualifications of managerial cadres in science and technology? How can we improve their professional competence and ideological standards?

Such are the key questions that the reform of local S&T commissions involves. We must constantly review experience and study it in depth as the new era requires.

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SCIENTIFIC RESEARCH CONTRACTING SYSTEM EXAMINED

Tianjin KEXUEXUE YU KEXUE JISHU GUANLI [SCIENCE OF SCIENCE AND MANAGEMENT OF S&T] in Chinese No 1, Jan 87 pp 18-21

[Article by Wang Shengqiao [3769 5116 0829]: "Issues to Take Note of When Implementing Contracting System"]

[Text] Ever since the reform of the scientific and technical system went under way, scientific research units have extensively adopted the compensation contracting system externally and research contracting system internally. The methods of contracting differ from unit to unit, as does the extent to which the system is implemented. Some units require a project group to be responsible for research funds, wages, and bonuses, even housing and equipment in certain cases. Other units stipulate the minimum amount of funds every person should pay each year. Meanwhile, the powers of the office director and project leader have been expanded correspondingly. People who achieve economic results are allowed to retain a larger percentage of profits as reward, while those who fail have to fulfill specified responsibilities. The compensation contracting system also applies to tasks assigned by the higher authorities; here rights and responsibilities are clearly spelled out. In effect this too is a form of contracting. There may be different forms of contracting but they are similar in essence, which is to link economic results to the personal interests of scientific and technical personnel and break their habit of eating out of the common pot, thereby mobilizing the enthusiasm of vast numbers of scientific and technical personnel and strengthening the orientation of science and technology toward economic construction. After over 2 years' practice, this method has definitely paid off. Nevertheless, a host of problems has also appeared. This article attempts to analyze the advantages and disadvantages of the contracting system (including compensation contracting) and addresses some of the issues that must be taken note of in the course of carrying it out.

I. It Must Be Clearly Understood That the Contracting System Is Only a Means, Not an End

The "Decision of the CPC Central Committee Concerning the Reform of the Scientific and Technical System" points out, "The basic goal of reforming the scientific and technical system is to apply scientific and technical achievements to production promptly and extensively, make full use of

scientific and technical personnel, greatly release the productive forces of science and technology, and accelerate social and economic development." Quoting Comrade Hu Yaobang, Comrade Zhao Ziyang said in his address to the conference on scientific and technical work, "To reform the scientific and technical system is to mobilize thousands upon thousands of soldiers and horses to go up the mountain to pick peaches." Actually these two statements mean the same thing, which, simply put, is that we must enlist the entire scientific and technical community to produce more achievements and apply them to economic construction. Such is the underlying goal of reforming the scientific and technical system.

Comrade Zhao Ziyang also said, "As for self-funding and so on, it is a means, not an end." Contracting is a form of self-funding, so it follows that it is also a means. It is important that we understand this point clearly because it affects the way we perceive contracting and the status we give it. A means serves an end. Whether or not a means is appropriate and to what extent it should be used naturally depends on whether the expected end has been achieved. To assess the contracting system, therefore, we must see whether or not the basic goal of scientific and technical reform has been achieved. Clearly we would be putting the cart before the horse and turning contracting into an end if we think that contracting is everything; that the more thorough its contracting system,the more advanced a research unit; and that once a unit attains complete financial self-sufficiency, it will be a success; or if we consider the contracting system the yardstick for judging a research unit.

II. The Contracting System Must Be Suited To the Characteristics and Laws of Scientific and Technical Work

Every object has its own characteristics and laws, and every reform must comply with the laws of development of the object concerned if it is to produce positive results. I have not examined how the contracting system got to be applied to scientific research work, but I guess it was inspired by the joint production system of contracted responsibility in agriculture. As we all know, this system of contracted responsibility has had an unprecedented stimulating effect on agricultural production and boosted agricultural productive forces enormously. The reason is that the system suits the laws of agricultural production in China. Does this system then comply with the laws of scientific research work as well? Let us compare scientific research work with agricultural production and see in what ways they differ, which will help us apply the contracting system even more successfully to the former. I think there are four major differences between the two: 1) The nature of labor is different. Scientific research work explores the unknown and is creative labor, while agricultural production is simple labor which involves using known technology and experience as a guide. 2) The methods of labor are different. Agricultural production is small-unit operation; it can be run by an individual, a household, or a few people independently and does not require coordination on the whole. Modern scientific research, on the other hand, requires coordination among various parties. A large project is possible only when several disciplines, special research units, colleges, universities, and enterprises cooperate among themselves. 3) The output of agriculture is material products; the output of scientific research is intellectual products, which have social as well as economic results. Besides, the economic results

of intellectual products are hard to estimate. 4) Agriculture (apart from a few state-owned farms) is largely collectively-owned, while the bulk of scientific research units are owned by the whole people. These differences are exactly what distinguishes scientific research work and must be taken into account when we carry out the contracting system in scientific research. Copying the agricultural experience mechanically and completely does not conform to the laws of scientific research and will necessarily backfire.

III. While Implementing the Contracting System, We Must Be Careful To Handle Several Relations Properly

Given the characteristics and laws of scientific research work, we must take pains to straighten out some relations if the system is to work effectively.

A. The relations between success and failure.

After the contracting system was adopted, scientific research personnel are held responsible for the success or failure of scientific research work. Whether the project in question is assigned from above, creating a vertical contract, or a job commissioned by an outside unit through a horizontal contract, its outcome will be linked to the personal interests of scientific and technical personnel. This is instrumental in enhancing their sense of responsibility and making sure that the task is completed on schedule, in contrast to the constant delays of the past when it was said that "scientific research can drag on from one year to the next." But it is just this accountability for success and failure that discourages researchers from accepting a job with less than 60 percent chance of success. Clearly they are more confident of tackling projects which are not too difficult, which emulate foreign technology, or which apply existing knowledge, while shying away from projects which are technically more complex, which are highly exploratory, or which are of a pioneering nature (let us leave aside basic research for the time being) because they are too risky. Since scientific research explores the unknown, the possibility of failure is inherent in it and examples of failure abound in the annals of scientific and technical development. Consequently in following the compensation contracting system, we must differentiate between individual cases according to their own particular circumstances. Where failure is not the result of sloth on the part of scientific and technical personnel or of disorganization and mismanagement, we must permit failure and should not go out of our way to lay blame. The national government should also launch research of an exploratory nature in new fields in a planned way and provide venture capital, assuming responsibility in case of failure. To allow only success and not failure does not square with the laws of scientific research.

B. The relations between individual initiative and group initiative.

After project contracting was adopted, the initiative of scientific and research personnel reached an all-time high. One after another they emerged from scientific research institutes and headed for factories to take up commissioned jobs and offer technical services. In the past, "research institutions were inaccessible." Nowadays not only are their doors wide open, but they also deliver technology to the door, largely ending the divorce

between technology and production. It should be noted, however, that we have not made use of research institutions as entities. In fact their role has been undermined. A research institute or center is an independent fighting entity. Below it are a multitude of research offices and staff agencies each with their specialties and jurisdictions, but all parts of the institute connected by organic ties and all serving its overall goals. A research achievement may come to fruition in a particular research office, yet it is actually the result of cooperation between related offices. Only when a research institute functions as a fighting entity can it truly bring out its strengths.

Because of layer upon layer of contracting all the way down to the group and individual, researchers and groups try to stay away from and isolate one another, ignoring the general interest for the sake of self-interests. Wherever coordination is required among the departments concerned, buck-passing has become routine and coordination is difficult. Thus organic ties between the parts are severed and the function of the research institute as a fighting entity is greatly diminished. It is possible for a single village or a lone individual to fight on its or his own in guerrilla warfare, but this kind of tactic is useless in a major battle.

C. Relations between producing and disseminating achievements.

After the first national trade fair on technical achievements last year, ministries, commissions, provinces, and municipalities have successively organized all kinds of achievements trade fairs for various disciplines, creating a very active technical market. The difficulties of disseminating achievements are now largely behind us. Particularly popular are those "short, level, and speedy" projects that require little investments and pay off quickly and handsomely. The volume of business generated is also impressive. But we should be sober enough to see the problem behind this boom, namely the question of technical reserves. For years we had been piling up a large number of achievements which failed to be popularized or were popularized in a limited area. Once the technical market was opened up, it seemed that we were awash in a sea of achievements. Yet as soon as these reserves are exhausted and not replenished, a crisis of achievement shortage will occur. In their impatience for economic results after the contracting system was adopted, scientific and technical personnel effectively have been selling off their goods in stock, while ignoring basic research and long-term scientific research projects that are time-consuming and require tremendous efforts with no prospects of benefits in sight. Some have even failed to keep up their expertise and professional equipment. While it is certainly important to apply existing achievements to economic construction, it is even more important to produce new achievements without which the technical market cannot be sustained. Scientific research of the past paved the way for today's "short, level, and speedy" projects, while tomorrow's "short, level, and speedy" projects depend on scientific research of the present. Therefore, scientific research personnel should be encouraged to undertake a number of long- and medium-range projects whose economic results are as yet invisible, and launch basic research in a planned way. Only thus can the technical level be improved continuously and a steady crop of high-standard achievements be assured. Not only must the state invest in these projects, but research

institutes themselves should raise funds on their own to support them. To require a topic group or individual to come up with achievements without investing in its or his work is no different than killing the goose that lays the golden eggs. If this continues, not only will there be no peaches after some years, but the peach trees may wither and die.

D. Relations between national tasks and horizontal contracts.

Key projects assigned by the state and other scientific research tasks (also known as vertical contracts) are major scientific research that affects the overall situation and impacts the development of science and technology and national economic construction. They must be carried out in full by scientific research institutions. Since they are the institutions' top priority, they should naturally be put before horizontal contracts. At present scientific and technical personnel show a great deal of enthusiasm for horizontal contracts but are reluctant to handle vertical contracts or engage in them half-heartedly. Behind this is a lopsided reward system. Horizontal contracting offers rich rewards and extensive personal benefits, whereas vertical contracting offers meager rewards, which of course dampens the enthusiasm to undertake national projects. Resolving this conflict takes a two-pronged approach. On the one hand, the state must draw up regulations setting up a reasonable reward system for national projects, (instead of simply shuffling off the conflict to subordinate scientific research units.) On the other hand, scientific research units should also adjust the reward system for horizontal contracts to put the two roughly on a par with each other. Only then can the relations between national projects and horizontal contracts be adjusted properly.

E. Relations between the economic results and social results of technical commodities.

Technical commodities have social as well as economic results. There is no relations of equal value between the two. Some commodities are short on economic results but long on social results. A certain new testing method, for instance, may be tremendously useful in promoting quality control and industrial development, but it has limited economic results. Low-standard repetitive research and unsound technology transfer and distribution which have appeared in scientific research work today may fetch impressive economic results for scientific research units, but they have minimal social results and may even be socially harmful. As units owned by the whole people, scientific research units must stay within the larger framework defined by the guidance, principles, and policies of the planned economy. They must neither put profit-making first, tackling whatever is profitable and shunning whatever is unprofitable, nor do things which benefit the part but not the whole.

IV. Some Suggestions

Our ability to handle the above relations satisfactorily is critical to making the contracting system a success. To do so, however, depends on the relevant policies of the authorities above as well as measures taken by scientific research units. Accordingly the following suggestions are put forward:

1. Clarify the strategic goals of scientific research units, draw up a development plan, and bring out the best of these units as fighting entities.

A major part of the effort by the CPC Central Committee to reform the scientific and technical system is to change the appropriation system so that "scientific and technical institutions develop the vitality to grow on their own and serve economic construction spontaneously." This is the strategic goal that scientific research units should strive to achieve. To do so, they must not only try to be financially self-sufficient totally, but also follow unwaveringly the direction of scientific research, as well as providing an endless supply of high-quality achievements and using them extensively in production to serve economic construction. None of this is possible if a scientific research institution does not function as a fighting entity, adapt to the new situation, and realize its strategic goal. Science and research institutions must first conduct market research to understand the demands made by national economic construction on technical development in the industry concerned. They must also analyze its strengths and weaknesses and, on that basis, readjust scientific research focus, do its best to exploit its strengths and sidestep its weaknesses, and draw up short-, medium-, and long-range plans. Based on its short-, medium-, and long-range tasks, it should also restructure itself, using economic and administrative tools, reorganize its corps of scientific and technical personnel, strengthen weak departments and those which are urgently needed, eliminate redundant personnel, make the best possible use of men and materials, and build itself up as a united fighting collective. It is certainly convenient and, for a while, possibly very economically rewarding, for everybody to go it alone by undertaking projects independently in a way that lacks long-term overall planning. In the long haul, however, our scientific research capability will diminish, scientific research standards will fall, and ultimately the scientific research unit may disintegrate.

Certainly this scenario may not happen to a particular unit, depending on its objective and subjective conditions. It may very well move in a different direction. As the "Decision" says, "Some may further develop into economic entities. Some may take cooperation one step further and merge with enterprises, or vice versa. Some research institutions may also build themselves up as enterprises of a scientific research type, or become the technical development arms of small and medium-sized enterprises." This kind of organization is in fact a form of enterprise somewhat similar to large corporations abroad which combine scientific research with production. The purpose of scientific research in this type of organization is to develop the company's technical services, not to serve society. In the main what it sells is material commodities, not technical commodities. Essentially this represents a change of direction by scientific research units.

2. Contracting must bring out the best in scientific research units as integral fighting entities and serve the realization of strategic goals.

Scientific research units differ from agricultural production teams. They are not managerial organs in government agencies. Accordingly they do not adapt well to contracting-by-layer, which in effect distributes allocated funds minus deductions by the higher authorities among the departments concerned,

layer upon layer, all the way down to the individual. The primary criterion for reward is the amount of money turned over to the higher level. No distinction is made between departments on account of their different nature. This method indeed helps stimulate the quest for economic benefits, but is unfavorable to scientific research overall and not viable in the long run. With money as its focus and money-making its target, it departs from the underlying goal of reforming the scientific and technical system and turns ends into means, and means into ends. A scientific research unit is a complete entity. The different positions in it may involve different tasks, but they all contribute to the overall strategic goal. There should be different contracting methods and different demands on different positions. For instance, apart from producing economic results, we must demand that scientific research departments continuously improve the quality and standard of results, complete on time and in the quality and quantity stipulated tasks handed down by the state as vertical contracts, and not be overly concerned about economic results. We demand that production departments turn out good-quality products and make a profit. As for service departments, we demand prompt quality services. In short, different departments should be judged by different criteria and carry out contracting based on different demands, instead of all going by the amount of money turned over to the individual. Only thus can the various departments pool their efforts and fight together for the achievement of the strategic goals of their research unit.

3. The reform of the appropriation system must be accompanied by relevant changes.

Practice proves that reforming the appropriation system can only enable scientific research units to develop the vitality to serve economic construction spontaneously, not the capacity for self-development. To do that, it must also depend on various related macroeconomic reforms. Take technical pricing, for instance. Prices today are negotiated on the technical market. Because the demand for technology by production departments is still less than urgent and owing to the influences of traditional ideas, technical products are seriously underpriced, which drastically lowers the incomes of scientific research units from technology and impairs their capacity for self-development. To solve this problem, we must do more than taking all sorts of measures to encourage enterprises to use new technology and increase their financial resources to pay for technical achievements. We must also step up theoretical and policy research on technical pricing, draw up a practical feasible technical pricing policy, and educate public opinion to ensure reasonable prices for technology. It is difficult to rely on the market alone to rationalize technical prices. In addition, we need to formulate and implement policies to reward personnel who take up national tasks or are in information work, standardizing, and quality control supervision. Wages are not enough of an incentive. The State Council has stipulated that a certain percentage of royalties from technology transfer be deducted as a reward, but has otherwise failed to lay down rules as to how the above personnel should be rewarded, a failure which has made some researchers less than enthusiastic. Scientific research units cannot solve these problems by themselves. The state must formulate relevant reward regulations without delay.

We must distinguish between different scientific research units and treat them accordingly. Two units may both belong to the development type, but if they have different tasks, their nature will also be different. A scientific research unit geared toward the technical development of an entire industry, for example, is usually required to assume information, standardizing, and quality-control supervision tasks for the industry as a whole in addition to planning for industry-wide development. For all intents and purposes it serves as an advisory organization to the central ministry and commission. Such a scientific research unit must be judged by its social as well as economic results. Consequently our policies should differentiate between research units and must not impose uniformity on them across the board.

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WU WUSHU DISCUSSES NEW SCIENTIFIC, TECHNICAL LEGISLATION

Beijing KEJI RIBAO in Chinese 20 Feb 87 p 1

[Article by Correspondent Liu Yuan [0491 1254]: "Nation in Process of Formulating Various S&T Regulations as an Important Part of Seventh 5-Year Plan Legislation"]

[Text] In an address to the 18 February All-China Scientific and Technical Legislation Research Work Conference, State Science and Technology Commission Secretary Wu Wushu [0702 2976 2885] made a request about future S&T legislative work on behalf of the NPC Education, Science, Culture and Public Health Committee and the State Science and Technology Commission. He said that S&T legislation forms an important part of Seventh 5-Year Plan legislative plans currently being drawn up by the NPC and the State Council. It is an important measure for the advancement of technology, for promoting technical progress and for bringing about the overall state control of S&T work.

Wu Wushu said that it was particularly important during the Seventh 5-Year Plan to devote attention to legislative work in two regards. One was to strengthen the building of basic legal institutions for S&T work such as "Technical Contracts Law," "Research Institutes Law," and "Scientific and Technical Mass Organizations Law." Second was to devote serious attention to the formulation of regulations urgently needed during the current period of reforms and liberalization, such as regulations regarding holding concurrent jobs, regulations on enterprises contracting with S&T personnel, regulations pertaining to the carrying out of "Spark Plans," and improvement of the system for appointments to specialized technical positions. The country has made very great progress during recent years in the work of formulating technical policies. In 1986, the State Council issued technical policies in several areas, and it will propose technical policies in some new areas during 1987. When conditions permit, some technical policies that have matured should be elevated to laws in the steady pioneering of new areas of S&T legislation.

He emphasized that future S&T legislation should be carried out in a planned, step-by-step way under leadership of the country's supreme legislative organs and its highest administrative organs.

He also said that the bolstering of S&T legislation is not only of major importance for the S&T world but is also of major importance to the legal world. He hoped that both parties would closely coordinate and work together in the future to advance S&T legislation work.

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METHODS SOUGHT TO LINK RESEARCH, PRODUCTION MORE EFFECTIVELY

Tianjin JISHU SHICHANG BAO in Chinese 14 Feb 87 p 1, 4

[Article by Management Science Research Office, National Research Center for Science and Technology for Development, State Science and Technology Commission: "The New Circumstances and the New Demands That Reform of the S&T System Faces"]

[Text] Pervasive reform of enterprises and the unfolding of administrative system reforms has wrought changes in the external environment for reform of the S&T system, and it has also made more possible the further linking of science and technology to production. In this connection, the Management Science Research Office of the National Research Center for Science and Technology for Development of the State Science and Technology Commission conducted a nationwide sampling of 379 independent scientific research institutions, 316 enterprises, and the scientific research organizations in 264 enterprises in the metallurgy, chemical, machinery, light industry and textiles, and electronics industry and in business. Results of a preliminary analysis are provided below.

Reform of the S&T System Has Impelled an Orientation of Scientific Research Toward Building the Economy and Has Benefited the Development of S&T Activities Per Se

As a result of reform of the S&T system, in the 379 independent scientific research institutions, the number of scientific research topics increased 75 percent; the level of scientific research rose 61 percent; the number of topics increased 47.8 percent; the difficulty of topics increased 57.6 percent; the average period of time spent on a topic was shortened 67.9 percent; self-determination of scientific research institutions was increased 50.1 percent; staff member and worker training opportunities increased 47.9 percent; and the standard of living of staff members and workers rose 82.1 percent. A trend toward greater diversity in the sources of scientific research topics also showed up. In addition to undertaking tasks assigned from above, accepting projects for which bids were called and contracts signed, and becoming involved in problems posed by enterprises, the percentage of self-selected topics has also been considerable.

Ninety percent of scientific research institutions mostly transferred technology to medium and small enterprises and to township enterprises; 78.2 percent of scientific research institutes mostly transferred technology for compensation, their own economic strength increasing as a result. Statistics show the three indicators of per capita earnings for institutions, institutes, and organizations, per capita income from transfers of technology, and per capita outlays for scientific research exceeded those for 1985 by 64, 66, and 80 percent, respectively. Further analysis may show even more remarkable results from those scientific research institutions that carried out reforms of their expenditures, and each of the indicators may be better than for those scientific research institutions that have yet to reform their expenditures, and be more outstanding in terms of per capita expenditures for scientific research, scientific research organizations' self-determination, and the standard of living of staff members and workers. Most of this category of scientific research organizations formed relatively stable cooperative relationships with enterprises, and transfers of technological achievements transcended departmental and regional boundaries to a marked extent.

Prevailing Science and Technology System Reform Policies Have Scored Definite Results; Nevertheless, They Still Do Not Satisfy Enterprises' Needs for Technical Advances

Inasmuch as China's economic system has yet to form a "benefit type" mechanism, since 1986, in particular, following a deepening of contradictions of a structural nature and a slowing of the development of the production of raw and processed materials, resulting in a shortage of marketable products etc., the production structure has not responded to changes in the consumption structure. As a result, among the 316 enterprises surveyed, the number enjoying brisk sales of products declined in 1986 and those having sluggish sales of products rose. In addition, according to a survey conducted by authorities concerned, of 40,000 key state-owned industrial enterprises included in the national financial budget, despite an increase in output value for the first 10 months of 1986, the total amount of profits and taxes declined slightly, and the number of enterprises losing money rose. This trend toward decline in economic results has forced enterprises to devote more attention to readjustments in their product mix and to hasten the updating and replacement of products. Consequently 70.8 percent of enterprises believe that their plants' strength in technology is of crucial importance to the enterprise's production operations.

Among enterprises having an industrial plant scientific research organization, those enjoying brisk sales of products numbered 38.2 percent and those having slack sales numbered 12.1 percent. For enterprises lacking a scientific research organization, those enjoying brisk sales numbered 15 percent, and those having slack sales numbered 21.9 percent. Enterprises expressing no need for technological development numbered only 2.7 percent.

As the external environment and internal conditions change, enterprises will have to form closer bonds with scientific research organizations. However, 59.7 percent of all lateral link ups between scientific research organizations and production enterprises today are principally ad hoc relationships based on market requirements; 21.6 percent are relatively stable

cooperative relationships; and 14.6 percent are joint scientific research and production organizations, jointly organized under articles of association. Only 1.6 percent are joint scientific research and production organizations with centralized administration and centralized accounting. Currently 77.8 percent of enterprises would like to have scientific research organizations enter the enterprise.

Step-by-Step Readjustment of the Organizational Structure of the S&T System Is an Objective Necessity for Development of the National Economy and Is a Major Task in Reform of the S&T System

Overall, 85.9 percent of enterprises and 64.8 percent of independent scientific research organizations advocate a change in the present organizational structure of the country's S&T system.

Most enterprises propose a merger of scientific research organizations for technological development with enterprises or with groups of enterprises. Most medium and small enterprises chose a scientific research organization of 50 people or fewer, and even though 92 percent of large enterprises already have their own technological forces of various kinds, they still have a need for different size research organizations.

As far as scientific research organizations are concerned, most scientific research organizations under jurisdiction of the State Council want to expand to become national industrial technical development and technical service centers, or else to combine with units concerned to conduct scientific research in technical, design, and engineering companies. Relatively weak organizations would like to merge with other scientific research organizations, combine with enterprises, or take over small enterprises in order to strengthen their own capabilities in development and trial manufacture. It is worth noting that 35 of the independent scientific research organizations surveyed expressed a desire to enter an enterprise or a group of enterprises, and 2 research organizations under prefecture or municipal jurisdiction acknowledged that they might disband for lack of proper conditions to conduct scientific research. The number of scientific research organizations desiring to enter enterprises remains a minority. They have misgivings mostly about whether the leaders of enterprises value S&T work and the role of S&T personnel, whether the self-determination of the scientific research organization might be curtailed, and whether there would be any improvement in pay and emoluments for S&T personnel. Survey of the 264 enterprise scientific research organizations showed such misgivings were not unfounded, with 23.2 percent expressing a desire to be free of the enterprise that they currently belong to, and 59.2 percent saying that their S&T personnel were dissatisfied with work in their present position. Thus, when encouraging independent scientific research organizations to enter enterprises, appropriate policy actions must also be taken, the vitality of enterprises strengthened, and solutions found to real problems and difficulties in the work and daily lives of S&T personnel in enterprises, a fine environment being created for the entry into enterprises of independent scientific research organizations.

Given the Present Circumstances of China's Science and Technology and Its Economy, Pervasive Reform of the S&T System Requires Attention In the Following Regards

--S&T system reform and economic system reform are interdependent and mutually conditional. Reform of the S&T system cannot await the enlivening of enterprises. Reform of China's S&T system has to be in keeping not only with the new situation of pervasive enterprise reforms, but must also set the stage for pervasive development of economic system reform and reform of the national administrative system.

--The close linking of China's modern S&T forces with development of the national economy requires a strengthening of technical innovation in industry, their real task being to help enterprises accelerate the updating and replacement of products, all-around improvement of economic results, and increasing the ability to earn foreign exchange from exports.

--Reform of the S&T system must advance hand in hand with the economic sector and with the S&T sector. It must proceed from China's economic, S&T, and social development strategy and be linked to readjustment of the country's industrial structure, the entire country's S&T forces (including enterprises and S&T forces in the civilian sector) must be equitably distributed, and avoid being restricted only to promotion of a "five major areas army" orientation in building the economy.

9432
CSO:4008/2079

NATIONAL DEVELOPMENTS

ACADEMY OF SCIENCES GIVES SHENYANG TECHNOLOGICAL ASSISTANCE

Beijing KEJI RIBAO in Chinese 9 Feb 87 p 1

[Article by Song Dezhong [1345 1795 0022] and Liu Xianda [0491 7359 6671] "Results Seen From Long-Term Technical Cooperation Between Shenyang Branch of the Chinese Academy of Sciences and Shenyang City; Reliance on Science and Technology For Vigorous Development of Economy For the Benefit of Both Parties"]

[Text] Since the signing at the end of 1985 of a long-term accord for S&T cooperation between the Shenyang Branch of the Chinese Academy of Sciences and the Shenyang Municipal Government, all institutes subordinate to the Shenyang Branch of the Chinese Academy of Sciences have made outstanding contributions to Shenyang City in its looking to science and technology for vigorous development of the economy.

Attention has been given to cooperation with planning, economic, and S&T departments concerned both in providing macroeconomic guidance and helping out on major S&T projects. The Shenyang Branch Academy has assembled the experts concerned to participate jointly with Shenyang City in drawing up and validating key S&T plans as well as plans for the technical transformation of key industrial enterprises during the Seventh 5-Year Plan. They have put forward numerous constructive ideas that have played a positive pioneering role in economic development.

In order to help do a good job on the key state transformation project during the Seventh 5-Year Plan--transformation of the Tiexi industrial area in Shenyang--the Shenyang Branch Academy assembled experts to take part in the formulation of plans. The industrial area's transportation control system has already been completed, and projects for an areawide information center and for ecological environment research have been made a part of the plan.

--New technological achievements have been transferred and used to tackle key problems jointly, giving impetus to the technical transformation of Shenyang's traditional industries. The microcomputer control system for controlling temperatures in the carburizing furnaces of the Shenyang Municipal Motor Vehicle Gear Plant, which was developed by the Shenyang Automation Institute of the Chinese Academy of Sciences, produced a finished product rate close to 100 percent, thus saving over 500,000 yuan per year in electricity costs.

--Assistance from "short, level, and speedy" technology to advance development of township industries. The Metals Institute of the Chinese Academy of Sciences assembled scientific research personnel to operate a metal products plant jointly with Daxing Village in Yuhong District of Shenyang. Technical standards for six of their products approached or exceeded levels for the same kinds of products made in Japan and scored outstanding economic results.

In addition, 27 specialists from the Shenyang Branch of the Chinese Academy of Sciences served as S&T advisors to Shenyang municipal administrative offices and bureaus. Seven S&T personnel served as technical leaders in pertinent enterprises in Shenyang and made positive contributions to Shenyang's economic and technical development.

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NEW LABORATORY CONSTRUCTION DETAILED

OW301042 Beijing XINHUA in English 0926 GMT 30 Mar 87

[Text] Beijing, 30 Mar (XINHUA)--China has built 20 national laboratories over the past two years and the construction of 22 others will be completed over the next three years, said Zhang Shou, vice-minister of the State Planning Commission, here today.

Vice-minister Zhang said the labs include the genetic engineering lab at Fudan University, the Solid Microstructure Lab at Nanjing University and the spectrum, atom and molecule lab of the Chinese Academy of Sciences, which were designated as labs open to the outside a year ago.

"The construction of key laboratories of the state is an important government measure in support of basic and applied research in natural sciences," Zhang told a working conference on national laboratories held in Beijing today. Since 1984, the state has selected a number of well-established laboratories from the Chinese Academy of Sciences, universities, and other research institutions to be reequipped with advanced research facilities. By the end of 1986, the state had invested 98 million yuan in these labs.

"We hope these newly-equipped labs will be able to take up the challenge of the state's key research projects and become the national experimental bases and academic centers," Zhang said.

Zhang suggested the national labs, when recruiting research staff, give priority consideration to Chinese students who complete their studies abroad.

"Most of these labs will be opened to international scientists, who will carry out research in frontier sciences at the international level," Zhang added.

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CSO: 4010/2016

CHEN YONG DISCUSSES SEISMOLOGICAL RESEARCH

Tianjin KEXUEXUE YU KEXUE JISHU GUANLI [SCIENCE OF SCIENCE AND MANAGEMENT OF S&T] in Chinese No 1, Jan 87 pp 33-35

[Article by reporter Yong Qian [0516 3677]: "Interview with Chen Yong, Deputy Director of the State Seismological Bureau, Hangzhou; Current State of Earthquake Forecasting"]

[Text] A native of Suqian, Jiangsu, Chen Yong [7115 9581] is a 44-year-old geophysicist. He graduated in 1965 from the Geophysics Department of the China University of Science and Technology with a major in geophysics and later worked at the Geophysics Institute of the Chinese Academy of Sciences. He was appointed director of the Geophysics Institute of the State Seismological Bureau in 1982 and became deputy director of the bureau in 1985.

He visited West Germany in 1978 and took part in an international conference on focal physics and rift mechanics. He was in the United States in 1979-80 doing research on the disposal of nuclear waste. He visited the Soviet Union in 1984 where he attended the 19th European annual conference on earthquakes. In 1985 he visited and lectured in Britain at the invitation of the Royal Society. Currently he is a director of the China Seismology Society and a member of the American Geophysical Association.

Chen Yong concentrates on focal physics and rock mechanics in his research and has published over 60 papers in domestic and foreign academic journals. His translations include "Rock Mechanics: Theory and Practice," "Brittle Solid Rift Mechanics," and "Introduction to Geophysics."

In recent years Chen Yong has developed an interest in management science and in the way natural and social sciences overlap. In 1985 he led a delegation to the United States to study at the National Science Foundation and has written a book entitled "A Brief Introduction to the National Science Foundation of the United States."

In early November 1986, I was invited to give a lecture to a leadership science course organized by the State Seismological Bureau at the training center in Hangzhou. As it happened, Comrade Chen Yong was there directing the course. I have always been uncertain about the scientific and social attributes of seismological research and earthquake forecasting, so I took

advantage of the opportunity to ask Comrade Chen Yong to talk about them at length.

Chen Yong said that the scientific and social attributes of seismological research and earthquake forecasting could be summed up in three sentences, "In terms of scientific attribute, earthquake forecasting is a scientific problem worldwide. In terms of social attribute, the occurrence of an earthquake is a highly complex social event. Because of these two characteristics, combining the scientific and social attributes of earthquake forecasting is an important approach in seismological research."

Earthquake Forecasting -- A Scientific Problem Worldwide

"First, the scientific attribute of earthquake forecasting. In the age of classical physics, provided the position of a heavenly body and the speed at which it traveled were known, people could, with the help of Newtonian mechanics, use these parameters to solve a second differential equation to predict its position at the next point in time and to forecast when astronomical phenomena such as solar eclipses, lunar eclipses, and the return of Halley's comet would occur. This is the concept of forecasting. Forecasting is based on the actual state of an object and its law of motion. However, as far as seismological research is concerned, we know very little about the interior of the earth. We may say that man is currently at a stage where he has found 'the road to heaven but not the door into the earth.' Our understanding of the interior of the earth is limited to what we can observe on the surface and our analysis and inversion thereof. The deepest hole we have drilled so far measures 12 kilometers in depth, which cost the equivalent of lining up 20-inch color TV sets for 60 kilometers. But since the diameter of the earth is 6,400 kilometers, what we have done has barely scratched the surface. Moreover, the insight we gain from drilling a hole is merely a drop in the ocean. Indeed we hardly know the way the interior of the earth moves at all."

"If that is the case, how should we evaluate the current state of seismological research?" I asked.

Chen Yong said, "Seismological research consists of two major areas, the first being seismological research as a scientific basis for earthquake forecasting, the second using earthquakes to study the interior of the earth to discover underground resources, such as oil, natural gas, metallic and nonmetallic mineral resources. Research in the latter has yielded numerous achievements. As far as I know, it engages more than 1 million people worldwide and costs upward of $10 billion each year. On the other hand, earthquake research per se languished in the state of pure science."

The change dated back to the 1960's. In 1960, an earthquake hit a densely-populated region in South America. Later, earthquakes also occurred in centers of population and industry in the United states, the Soviet Union, China, and Japan. In the past, most earthquakes happened along a plate, usually in the oceans, and caused relatively little damage. Major earthquakes after 1960, however, have killed or seriously injured over 1 million people, not to mention those who were slightly hurt. Out of political, economic,

scientific, and social considerations, governments of the world began to take earthquake forecasting research seriously. Since the 1960's, Japan has been implementing 5-year plans on seismological research, while the United States has set up a special policy-making body. In China, seismological research has also entered a new era, with the government attaching much weight to the matter. What then is the current state of earthquake forecasting? Some earthquakes give out forewarnings. In other words, a major earthquake is preceded by minor tremors which we call foreshocks. We can make long- and short-range forecasts about this kind of earthquake and inform the government and masses beforehand. The Haicheng earthquake is a typical example. Because the foreshocks were carefully monitored and forecasts were made, the lives of almost 10,000 people were saved and losses were cut by over 1 billion yuan. But earthquakes like this which can be forecast accurately a short time in advance make up a very small portion of all earthquakes, from one-quarter to one-third by my estimate. There is still a large percentage of earthquakes which we cannot predict accurately at short range before they occur. One example is the Tangshan earthquake. Looking back now, the main problem there was one of scientific standard, that's all. Regarding the current state of earthquake forecasting, we can say that we have to fall back on experience primarily, which is limited. Hence there have been both successes and setbacks. This situation will continue for a long time to come."

Earthquakes -- A Complex Social Event

Chen Yong said, "My second sentence is that an earthquake is a complex social event. A natural disaster such as an earthquake differs from a typhoon, storm, or flood. Its first characteristic is suddenness; an earthquake may be over in a matter of seconds or minutes at most. Secondly, it affects a wide area. A seismic wave spreads over a huge area and, radiating from the epicenter, may circle the earth twice before diminishing in intensity; the Tangshan earthquake shook Beijing and Tianjin and was felt by much of the country. Historical records put the death toll from the earthquake in Hua County in 1556 at 830,000, a figure which included only males eligible for conscription: Household registers at the time excluded women and children as well as the elderly and weak. This earthquake would have registered 8 on the Richter scale and was much more severe than the Tangshan earthquake. According to local county records, over 300 counties were affected by it, which gives us an idea of the vastness of its impact. It is exactly because of these two characteristics that an earthquake is a major concern to everybody and has become a critical social issue."

"Two examples. At an international conference in Mexico in 1980, a young U.S. scientist named (Buleidi) predicted that Lima, the capital of Peru, would be struck by the worst earthquake of the century in 1981. Reporters got wind of this and it became headline news in every newspaper. As a result, embassies scrambled to evacuate their staffs, the wealthy bought planes and ships, and food was sold out in a wave of panic buying; society was paralyzed. The president of Peru sent a special plane to bring (Buleidi) to Peru and demanded that the U.S. government issue a formal explanation. The Peruvian press was all worked up; banner headlines appeared in the papers demanding that '(Buleidi) be hanged if no earthquake happens.' Later the U.S. government assembled a review panel of scientists and explicitly rejected (Buleidi)'s

forecast. This incident had strong repercussions in the United States as well; in a subsequent report, the U.S. government pointed out that earthquakes not only causes death, injuries, and material losses, but also damages a government's political function for a period of time. The second example occurred in May this year when it was rumored that a major earthquake was going to hit Shanghai. According to one report, the Chinese government takes earthquakes very seriously behind the scenes but appears casual about it outwardly. Thus it made no advance announcement in order that the masses could get on with production undisturbed. Meanwhile, the Voice of America and NHK radio had also carried this news item. Another theory was that two rifts appeared in Shanghai in the first half of the year as a result of an earthquake in the Taiwan Strait. People felt the vibration but did not ask where the epicenter was, assuming that the quake happened in Shanghai. The third story was that the weather in Shanghai was abnormally hot. For a time hotels in the city were deserted, nobody turned up at school to take examinations, and the words of factory leaders and the municipal CPC committee were unheeded. Even the wives of people who worked at our office of seismological analysis in Shanghai did not believe their husbands, saying that they were not telling the truth. Over 80 percent of the people in the city were affected. Shanghai demanded that the State Seismological Bureau issue an explanation. The masses do not listen to party or government leaders in this kind of situation; they want to hear from authoritative scientists. That is why party and government agencies at all levels are highly supportive of seismological work."

"The time following an earthquake provides a good opportunity for social observation and research. I hurried to the scene 8 hours after Tangshan was hit by an earthquake. The bulk of the buildings there had been reduced to ruins; survivors sat on the roadside in silence, without making a sound. Even the dogs did not bark. Only one person among the leaders on the Tangshan prefectural CPC committee and in the municipal government was slightly injured; the others were either seriously injured or killed. Prison cellblocks were still standing, but the guards were dead. In the absence of government, what was good and beautiful burst forth like sparks, but there was also an epidemic of ugly hideous events, including robberies and thefts. Some covered themselves with watches from head to toe. Others ignored their relatives and came forth to maintain social order. I personally witnessed seriously wounded militiamen guarding banks with iron spades and wooden sticks. All this was a wealth of material for those searching the conscience and ethical values of man."

"Earthquakes are complex social events involving every social stratum and every area of work. For a limited period it may be the top social concern. In the 10 years since the Tangshan earthquake, over 1 million copies of Qian Gang's [6929 6921] "The Great Tangshan Earthquake" have been sold precisely because it strikes a responsive social chord."

Chen Yong said, "My third sentence is that combining its scientific and social attributes is essential to the development of seismology. In terms of social need, the masses and government demand that seismological workers produce accurate forecasts to avoid disastrous losses. Given seismology's current state, this demand cannot be met. The result is a big problem. In the realm

of science, many sciences are practically applied only after they have matured. But there are also some sciences which are put to use even as they mature. Both the diagnosis and treatment of cancer and the forecasting of meteorological conditions that may cause disasters fall into this category. So does seismology. The solution is to combine its scientific and social attributes."

Uphold the Scientific Policy toward Earthquake and Make It Serve Socialist Construction

Chen Yong said, "The principle of China's earthquake policy is this: Use every method and every tool to reduce earthquake danger to the absolute minimum. There is no consensus among scientific communities around the world regarding the way to prevent earthquake disasters. Some people suggest that since it is presently impossible to predict an earthquake, we should simply not bother with forecasting and instead fight earthquakes with building reinforcement. Whether this can be done depends on economic strength. No nation is economically powerful enough to reinforce every single building so that it can survive an earthquake of the magnitude of the one that hit Tangshan. We propose combining earthquake forecasting with building reinforcement, determining the different degrees of reinforcement for buildings in different areas according to the historical distribution of earthquakes. As far as short-range forecasting is concerned, we should do what Haicheng has done. Information on the probability that a certain area would be hit by earthquake is published just about every year, but we cannot pin down the month or day. We cannot demand that the government acts in accordance with long-term trends. Take Beijing and Shanghai, for instance, where daily output value reaches 100 million yuan. Any call for work stoppage must be dealt with seriously. Short-range forecasting depends mainly on observed changes in the geophysical field and chemical field and detected abnormal phenomena in nature which we call foreshocks. It is not enough to depend on professional workers alone to detect foreshocks. Living creatures' abnormal behavior, the flashes of light preceding an earthquake, and changes in water level and quality--all this can be observed by the man in the street. Hence it works to mobilize and rely on the masses to monitor foreshocks. This is also a characteristic of Chinese seismological work. But it must be emphasized that enlisting the masses in foreshock detection must be based on long- and medium-range forecasts. Never should we mobilize 1 billion people to keep an eye on these things day after day. They may come up with many illusions, creating mass panic and disrupting normal social life."

Chen Yong further stressed that "leftist" influences must be eradicated from the mobilization of the masses to monitor foreshocks. "A few years ago we had such concoctions as 'indigenous telluric electricity,' 'indigenous geomagnetism,' and 'indigenous geodeclination.' According to some people, where science cannot give us a clear answer, the more indigenous the method, the better. It is unscientific to elevate things with no scientific basis to an inappropriate level. We held a conference last year where scientists were asked to evaluate these things one by one. It was decided that we should discontinue doing whatever had no scientific basis. We ask the people to observe water because changes in rock formations are reflected in the physical and chemical properties of water. Over 400 enterprises across the nation are

doing water chemical analysis for us, which constitutes a kind of 'byproduct' for those enterprises. We have more than 200 wells across the nation so that we can keep clear records on earth tide and lunar tide. We also recommend that people observe animals, paying attention to their group behavior: One animal in itself is no basis for making a judgment. All data derived from observations should be sent to the State Seismological Bureau for processing and analysis."

"We must also tackle long-range forecasting and estimate the danger of earthquakes for different areas of the nation. In each coastal city, key projects should be handled individually depending on their geological conditions; those on a good geological foundation need less reinforcement, while those on more shaky ground should be accompanied by better protective measures. This is small-area planning. In addition, we must analyze and study the sites of major projects and come up with countermeasures. For instance, we must check the fault fissures within 320 sq km of the Daya Bay Nuclear Power Station, one by one. This is the stuff of earthquake engineering. We have a 4,000-person research center engaged in this task to ensure the safety of key state investments."

Advance in the Face of Difficulties; Develop Seismology

Chen Yong said, "Seismological work is crucial but arduous. Most of our seismological stations are located in remote, thickly forested mountains where living conditions are tough. Seismological workers even have trouble finding a mate or a convenient school for their children. The problems of earthquake forecasting probably will not be solved in our generation. There is no lack of people in China's corps of seismological workers who have devoted their whole lives to this enterprise. Their noble spirit is admirable. Some of them have quietly worked for 20 or 30 years and are the backbone of the seismological corps."

"We have discussed the scientific and social attributes of seismological work. It is hoped that seismological workers would heighten their sense of social responsibility. On the one hand, hopefully more people will involve themselves in research directly related to earthquake forecasting. On the other hand, we hope that they develop a serious attitude toward earthquake forecasting. It is a critical task which has no room for consideration of personal interests."

"We must recognize the current state of seismology, allow differences of opinion where scientific matters are concerned, and encourage scientific exploration. Under no circumstances should a difference of judgment regarding an academic point be elevated into a political issue. To resolve an argument, we should appeal to science, not adjudication by the leaders, and certainly not the support of some foreigners."

Chen Yong finally said, "Seismology has social attributes: There is widespread interest in it at all social strata and everyday we receive thousands upon thousands of letters. We hope that the press and the cultural community help us build bridges to all quarters in society so that we get to understand society, and vice versa. Together we will make the seismological enterprise a success."

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HEBEI RESEARCH UNITS PUT ON BUSINESSLIKE FOOTING

Beijing KEJI RIBAO in Chinese 20 Feb 87 p 1

[Article by Li Guozeng [2621 0948 1073]: "Hebei Development and Research Units Institute a General Compensatory Contract System; Effort Placed on 'Enlivening' and an Issue Made of 'Orientation'"]

[Text] Reforms made during 1986 in Hebei Development and Research Units followed a program of "readjusting, restructuring, consolidating, and improving." These reforms centered around various already existing policies, placed efforts on "enlivening" and made an issue of "orientation," again scoring fine achievements.

Complete reform of Hebei Province's funds disbursement system has been launched; the work of apportioning and forwarding scientific research operating expenses has been completed and institution of item-by-item control of research institutes has begun. During 1986 development and research unit operating expenses were reduced 51.3 percent in a 74.7 percent increase over 1985 in the percentage of reduction of operating expenses. Institutes installed general compensatory contract systems in their external dealings. Internally, they installed a task contracting system, and 110 institutes installed institute director responsibility systems. Most institutes had self-determination with regard to appointments and dismissals of middle-level cadres, the readjustment of direction and tasks, the setting up of an internal structure, the drawing up of scientific research plans, external technical services, the transfer of research results for compensation and the establishment of lateral relations with production units. The far-flung S&T personnel left research institutes to go to industrial plants and rural villages to work on various kinds of key technical problems, and to engage in technical development and technical service activities. They have been well received by a wide range of medium and small enterprises and by township enterprises.

Statistics show that during 1986 these 110 research institutes established lateral relationships with 978 production units and conducted 1,629 separate scientific research tasks. Evaluated and accepted research achievements numbered 919 and earnings from technology amounted to 11.85 million yuan.

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CSO:4008/2079

GUANGDONG TECHNICAL ADVANCES SHOWCASED IN BEIJING

OW061100 Beijing XINHUA in English 1040 GMT 6 Apr 87

[Text] Beijing, 6 Apr (XINHUA)--Beijing residents now have a chance to check out 3,000 products manufactured by Guangdong's foreign-funded enterprises.

"The exhibition from Guangdong is the first of its kind held in the capital to show the results of foreign investment and technology," an exhibition official said, adding 1,300 of the province's 2,000 enterprises funded with foreign investment have set up displays.

The 15-day exhibition, which opened yesterday features 18 booths sponsored by the province's 18 prefectures and cities, the official said.

Guangdong, China's most important area open to foreign investment and technology, has absorbed US$4.3 billion in foreign capital from 20 countries since 1979, when the central government empowered the province with flexible policies to promote foreign economic cooperation.

Guangdong is responsible for 66 percent of the country's total foreign capital over the past few years, and foreign investment accounts for 20 percent of the province's total investment in the fixed assets of state-run enterprises.

By the end of 1986, the province had imported 500,000 pieces of equipment and 700 production lines to build a number of new factories.

"These imports have promoted the technological upgrading of existing enterprises and the development of new products," the official said, "and to date, about 10,000 new products have been developed, of which 1,214 are on display at the exhibition."

Last year, Guangdong's total industrial and agricultural output value was 2.47 times more than in 1978, with an annual average growth rate of 12 percent, higher than the national average, and its exports have more than tripled.

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CSO: 4010/2016

HUNAN S&T CONFERENCE OPENS

HK260742 Changsha Hunan Provincial Service in Mandarin 1100 GMT 24 Mar 87

[Excerpt] A provincial conference on scientific and technological work opened this morning in Changsha. Over 200 people attended the conference. They included scientific and technical personnel from all areas throughout the province and responsible comrades from party and government departments responsible for science and technology. (Wang Ruiming), deputy director of the General Affairs Bureau under the State Scientific and Technology Commission, made a special trip to Changsha to attend the conference.

Vice-Governor Wang Xiantian, presided over the conference. (Tao Ming), chairman of the Provincial Scientific and Technological Commission, delivered a work report entitled "Deepen Reform of the Scientific and Technological System to Serve the Revitalization of Hunan's Economy."

Provincial Governor Xiong Qingquan delivered an important speech at the conference. Over the past year, our province scored remarkable achievements in science and technology. Last year, Hunan was directly involved in over 3,000 research and exploration projects, with an output value of 1,167 million yuan and a tax revenue amounting to 215 million yuan. Of the province's 464 spark plan projects launched last year, 127 are state and provincial-level projects, and 67 projects were completed in that very year, thus producing an output value of over 82 million yuan, with a tax revenue amounting to over 13 million yuan. Hunan received 1,700 applications for patent rights. Of them, 232 applications were approved, thus enabling Hunan to win fourth place nationally.

In his important speech delivered at the conference, provincial Governor Xiong Qingquan called on scientific and technical personnel to be responsive to the needs of our economy, and to use their knowledge and abilities for making even greater contributions to the revitalization of Hunan's economy.

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SHANGHAI BECOMES IMPORTANT 'GATEWAY' FOR ADVANCED TECHNOLOGY

Hong Kong LIAOWANG OVERSEAS EDITION in Chinese 2 Mar 87 No 9 pp 17-18

[Article by Shen Shiwei [3088 0013 4885]: "Shanghai Becomes Important Gateway for Importing Advanced Technology"]

[Text] Shanghai, the largest of the open cities, is experiencing great momentum in bringing in foreign capital and importing and absorbing advanced foreign technology. To date, the city has absorbed more than $1.85 billion in foreign capital, and more than 470 cooperative projects have been signed. As of the end of last year, the city had approved the creation of more than 220 exclusively foreign enterprises, Sino-foreign joint ventures, and cooperative enterprises; of these, more than 100 have already gone into production or operation. Virtually all these new joint ventures are yielding excellent economic results and have achieved an overall favorable balance in foreign exchange.

In Shanghai's economic circles, it is believed that importing and absorbing advanced foreign technology has strengthened Shanghai's domestic position in technology. It is now becoming a major gateway for the utilization of foreign investment and importing advanced foreign technology, and a bridge for transferring inland these advanced technologies and management methods. This is one major result of Shanghai's diligence in establishing an export-oriented economy.

Developing New Knowledge- and Technology-Intensive Industries

As China opens to the outside, Shanghai has given priority to absorbing knowledge- and technology-intensive new projects, particularly those in the high-technology field. The foreign capital being invested in Shanghai has undergone a striking change: it is moving away from the startup of tertiary industry toward industrial cooperative projects, and from small and medium-size enterprises providing ordinary technology toward knowledge- and technology-intensive projects.

At present, many of Shanghai's joint ventures and cooperative projects with foreign businessmen are knowledge- and technology-intensive enterprises, and some are high-technology enterprises. For example, a Shanghai-Hong Kong joint venture that went into production recently, the Huxing Electronics Corp,

specializes in producing floppy disks for computer information storage. This company was formed by combining the Huangpu Instruments Plant, the Shanghai Trust Consulting Co of the Bank of China, and the Mianxing Magnetic Tape Corp of Hong Kong; it imported production technology and key equipment at 1980 international levels from the United States. The floppy disks manufactured by this company are now sold on the international market. The contract for the largest Australian-run cooperative project in Shanghai, a circuit-board plant with an annual output of 30,000 spqare meters, was recently signed in Shanghai. This plant will be cooperatively run by the Shanghai No 20 Radio Works and the PCL Co of Australia; it will adopt advanced foreign technology and methods to produce high-precision, high-intensity, high-reliability double-sided and multilayer boards. When the plant goes into production, it will play an important role in developing the microelectronics industry in the Shanghai region. The opening of the Shanghai Wang'an Computer Development Corp, created through joint investment by the Shanghai Computer Co and the Wang'an Zhongguo Corp, has attracted particular attention. This company is a high-technology enterprise designated by the Ministry of Electronic Industry that produces primarily small, Chinese-language VS computers. In the future, it will move into producing the Wang'an line of computer products and will develop application software for domestic users. The initial batch of products produced by this company will be marketed by the Shanghai Computer Co.

Construction plans for the so-called "Shanghai's Silicon Valley," the Caohejing Microelectronic Industrial Park, are now being implemented. This high-technology area will centralize development of computers, large integrated circuits, optical-fiber communications, and other new industries, to gradually form a high-technology "window" for Shanghai. To date, more than 30 foreign companies and enterprise groups have visited the site and are discussing projects. The U.S. National Electronics Association and the U.S.-China Investment and Trading Co will recruit a number of high-technology multinational corporations and groups with worldwide influence to open an international information exchange center at the Caohejing Microelectronics Industrial Park, set up a technology consulting structure, and carry out international exchange and cooperation in microelectronics and other high technologies; ground has been broken and construction started on the large integrated circuit base project imported from abroad.

In order to encourage foreign businessmen to establish knowledge- and technology-intensive enterprises, the Shanghai government is offering a preferential policy: it stipulates that, outside of the city's more bustling areas, land-use fees for advanced-technology enterprises will be waived for 3 years from creation of the enterprise; beginning in the fourth year, fees will be paid at 50 percent below the standard rate, not to exceed 2.5 yuan per sqare meter.

Bringing in Foreign Capital Through Multiple Channels

Another particularity coming to the fore in Shanghai's opening to the outside is that the introduction of foreign capital has entered a stage of multiple channels and variety. When Shanghai brought in foreign capital in the past, direct investment by foreign businessmen was much more common than indirect investment. According to statistics from the departments involved, by the end

of 1985 there were more than 160 approved direct investment projects from abroad, the investments amounting to $1.2 billion; although there were more than 190 indirect investment projects, they totaled only $100 million. In order to change this situation, the State Council gave its approval to Shanghai to raise capital directly from the international financial markets, with Shanghai doing its own borrowing and repayment and taking responsibility for its profits and losses; it also adopted varied modes of investment, gradually giving the utilization of foreign capital a new, varied, and multichanneled structure. Shanghai now makes use of the following means of raising capital:

--Issuing bonds abroad. The Shanghai Investment Trust Corp issued bonds worth 25 billion yen in Japan; this is the first time that Shanghai has tried raising capital in the international financial market. The bonds bore a face-value interest rate of 6.6 percent, with a term of 10 years. The bond issue has continuously maintained its full value in the Japanese securities market. The Shanghai Investment Trust Corp is using this capital to support industrial enterprises capable of exporting to generate foreign exchange in carrying out technological upgrading. This company has signed more than 30 loan agreements with such industries as metallurgy, chemicals, textiles, and household appliances, with loans totaling $240 million.

--For projects having the capacity for loan repayment and generating foreign exchange, foreign commercial loans and World Bank loans may be utilized. For example, the Shanghai branch of the Bank of China raised 13.6 billion yen through the Mii Bank of Japan for the Duanjin Building and the Asia Hotel in Shanghai; from the Hanover Bank of the United States, the Industrial Bank of Japan, and the Bank of Tokyo, it also raised more than $160 in foreign exchange for the Pacific Hotel, the Yangzijiang Hotel, and the International Trade Center.

--For certain projects lacking the capacity for repayment and generating exchange, the approach adopted involves greater use of long-term, low-interest loans, both intergovernmental and from international financial institutions.

Shanghai's varied, multichanneled approach to bringing in foreign capital has attracted the attention of foreign financial and banking groups. France, Japan, the United States, Sweden, and other countries have now opened more than 20 bank branches and offices. They handle primarily exchange operations and raise foreign capital for Shanghai.

Focusing on Intellectual Investment

In the conference room of the Shanghai Electromechanical Plant, the people in charge of the various shops and departments are listening to a diagnostic report from a foreign consultant. The person giving the report is Ai-xi-tuo-ma-ya [1947 6007 5192 3854 0068], director of the dynamo plant of the Westgate Co of West Germany. He was hired by the Shanghai Electromechanical Plant as consultant to the plant director. After familiarizing himself with the plant, the foreign consultant offered pertinent comments on how the plant should establish a personal responsibility system and improve enterprise management. When the consultant had finished, he placed on the table some small tools,

quartz watches, briefcases and other small gifts and asked the plant director, Li Wenhua [2621 2429 5478], to turn them over to those people who contribute the most to improving the plant, and said, "The people who hope to get these gifts have to be the best workers!" The audience immediately came alive.

This is a vivid description of how Shanghai is focusing on importing knowledge, which is another characteristic of Shanghai's intensive opening to the outside. Since 1984, there have been 44 projects that have brought skilled personnel to Shanghai, with more than 90 foreign experts being hired. This has had a positive effect on Shanghai's development of its economy and of new technologies. The Shanghai Petrochemical Works hired Chinese-American experts to undertake renovation of its vinyl cyanide installations, which led to a sharp increase in output and yielded more than 10 million yuan in additional profits each year. The Shanghai Lubricating Equipment Works hired foreign experts as consultants to assist the plant in designing and developing new products in order to bring the plant's products up to 1980 levels. By importing knowledge, Shanghai's engineering and technical personnel have expanded their field of vision and raised technological levels.

13322
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AIR FORCE REMOTE SENSING MISSIONS AID CIVILIAN ECONOMY

Beijing KEJI RIBAO in Chinese 20 Feb 87 p 1

[Article by Correspondent Zhu Hao [2612 3185]: "Air Force Provides Civilian Sector With Remote Sensing Flights; Plays Role in Surveying and Mapping National Resources"]

[Text] The correspondent recently obtained the following from Air Force units concerned. During the past several years, the Air Force has provided technical services in the form of remote sensing flights to 9 national departments and 21 provinces, municipalities, and autonomous regions, playing a major role in natural resources surveys, in monitoring pollution of the atmosphere and the marine environment and in mapping.

The term remote sensing flights means an airplane's discharge or echoing of certain kinds of energy from a distance without making contact with the target being probed, converting it into images or signals that can be readily identified and analyzed, thereby clarifying the nature and characteristics of the target.

During the past several years, the Air Force has completed 63 remote sensing sorties on behalf of the civilian sector, the main projects being remote sensing of turbid rivers in Jilin Province and of minerals in the Changbai Shan Region, a survey of the status of the "Three Norths" shelter forest in the Pingquan area of Hebei Province, a survey of the distribution of coal reserves in the Taihang Shan region, and estimating the autumn harvest on the North China Plain. Quite a few of these projects have been in the nature of key national scientific research or construction projects. An airborne experiment involving the "Practice No 3" satellite television remote sensing digital transmission required simulation of the flight attitude of a satellite flying in space. Requirements on direction, speed, and altitude of flight were very strict. The Air Force dispatched 7 aircraft sorties to fly painstakingly for 14 hours under different visibility conditions to validate the practicality of using a satellite television remote sensing system in prospecting for resources. The Air Force flight crews that undertook the task of aerial remote sensing of geological structures in the lower reaches of the three gorges of the Chang Jiang discovered fault zones that provided scientific data for deciding the future location in the three gorges of a water-lift dam, and earned the praise of leading comrades in the central government and party.

The Air Force also conducted aerial remote sensing flights in China's famous forestry region, the Dongting Hu Plain. "Maps of the Dongting Hu Region," and "Maps of the Dongting Hu Region Water System," drawn from remote sensing images have become important data for planning, control, and flood prevention work in the Dongting Hu region.

9432
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'MOONLIGHTING' BY S&T PERSONNEL ENCOURAGED

Beijing KEJI RIBAO in Chinese 9 Feb 87 p 2

[Article by Correspondent Bie Qinghe [0446 3237 3109]: "Advantages Outweigh Disadvantages in Afterhours Employment of S&T Personnel"]

[Text] In recent years, more and more S&T personnel have taken second afterhours jobs. Statistics show 10 to 20 percent, 50 percent in many cases, and as much as 70 percent of all S&T personnel in units subordinate to the Beijing municipal government as holding afterhours jobs. They take part in afterhours jobs primarily in the following ways: First, their unit organizes employment in a planned and guided way; second, some social organizations take the lead in organizing employment; and third, S&T personnel accept invitations to take a second job in a unit other than their own.

The afterhours employment of S&T personnel came about in response to needs generated by pervasive reform of the economic system and the S&T system. On the one hand, market competition impelled countless township enterprises and medium and small enterprises to the large-scale adoption of applied technology and new technology. On the other hand, approximately 30 percent of S&T personnel of all kinds were not fully occupied and, for a time, it was difficult for them to move in a rational way into the units that needed them. Given these circumstances, with one party needing personnel and the other party needing jobs, the two blended together.

Practice has shown benefits to be numerous from S&T personnel holding two jobs so long as they first complete the work in their assigned positions:

1. Afterhours work is a fine means for transferring intellect and skills. It is easier and more feasible than movements of skilled personnel. One might say that it is using "nearby water to slake nearby thirst." Enterprises in Nanyuan Village in the Fengtai District of Beijing formerly found it difficult to get ahead because of a severe lack of S&T personnel. Subsequently, these enterprises adopted flexible methods, inviting more than 100 S&T personnel to do afterhours design, consulting, and training work. Within the short space of 3 years, these enterprises developed considerably, and during 1986, primary level enterprises alone paid the state more than 20 million yuan.

2. Afterhours work helps S&T personnel utilize the full extent of their abilities, their talents being used to the utmost. The technical translation department of the human talent development center in the Beijing municipal

industrial system organized various kinds of technical personnel to use their spare time to translate large quantities of technical data for key national construction projects including the Capital Iron and Steel Plant and the Antaibao Open Pit Mine in Shanxi and for technical imports. This solved a pressing problem for these units; it also prevented the skills of the afterhours S&T personnel from becoming rusty and made full use of their role.

3. Afterhours work helps demolish the walls around scientific research work, enabling S&T personnel to polish their professional skills and their level of scientific research. While holding two jobs, S&T personnel in the Beijing Municipal Labor Protection Research Institute chose a large number of scientific research topics for which an urgent social need exists, that is, they helped production units solve many technical problems while improving their own scientific research skills. During the past several years, this institute has scored several hundred scientific research successes.

4. S&T personnel holding two jobs have increased earnings, and this is of very great significance at a time when it is very difficult for the country to appropriate more money for further improvement of the living conditions of S&T personnel.

Data provided by the Beijing Municipal Township Enterprises Bureau show no fewer than 80 percent of the 18,000 township enterprises under this bureau as playing a key role as a result of S&T personnel holding two jobs of various kinds. The employees of these enterprises, who number in the millions, pay the state profits and taxes of several hundred million yuan each year, and the products of these enterprises have become an indispensable part of the national economy, with some of them entering international markets.

Some problems have also risen in afterhours work by S&T personnel. For example, in some cases work in their own unit has been adversely affected or impaired; illegal forms of withholdings from legal income have been used; and some personnel who hold two jobs have infringed the technical and economic interests of their parent unit. The lack of checks and inspections has resulted in an extremely tiny number of S&T personnel transferring not fully developed "results" of research in consequence of which the receiving units, particularly some township enterprises, have suffered losses. etc. These problems occur largely among S&T personnel who have arranged for their own employment in the second job. Units concerned should intensify criticism and indoctrination of these personnel and draw up as quickly as possible appropriate policies and regulations to provide them rules to follow.

These problems are a long way from being the main trend in the afterhours employment of S&T personnel, however. A check by the correspondent with units such as the Beijing Municipal Scientific and Technical Cadres Bureau showed the foregoing problems to exist among no more than 10 percent of S&T personnel holding afterhours jobs. Furthermore, as soon as such problems have come to light, in most cases they have been conscientiously and strictly dealt with and corrected at once.

To summarize the foregoing, even though problems of one kind or another have arisen in the afterhours employment of S&T personnel, overall, observation and analysis show advantages to outweigh disadvantages.

RARE MAGNETS BEING EXPORTED

Beijing CHINA DAILY in English 19 Mar 87 p 1

[Text]

A company under the Chinese Academy of Sciences recently exported 1 million yuan worth of neodyminum-iron-boron magnets, making China one of the few producers and suppliers of this rare and recently discovered magnet material in the world.

Neodymium permanent magnet materials are the latest development in high energy magnets and the most cost-effective high energy magnet on the market today. They were first discovered in 1983.

The United States and Japan have invested millions of dollars in developing the material. the European Economic Community is organizing 53 laboratories in 12 nations to carry out research. Western experts expect that by the early 1990s, neodymium permanent magnets will capture 50 per cent of the magnet market. Commercial application of the material is increasing. The magnets are being used by manufacturers of motors, telecommunications and computer equipment, accoustic devices, consumer durables and other products.

The Sanhuan Corporation for research and development of new materials, under the Chinese Academy of Sciences, successfully developed a low grade magnet of this type. "This greatly reduced the cost of raw materials and our technology was also a breakthrough," said Wang Zhenxi, president of the corporation.

The Sanhuan Corporation has developed a variety of neodymium magnet alloys and is beginning large-scale commercial production. "Entering our products in the world's market will have a significant impact on establishing a high-tech industry in this field in China," Wang said.

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DISTRIBUTION OF SCIENTISTS, ENGINEERS DISCUSSED

Little Freedom of Movement

Beijing CHINA DAILY in English 23 Mar 87 p 4

[Article by Niu Qiuxia]

[Text] When all agree that there should be a flow of talented manpower in the country, views still differ as to how.

With increasing autonomy, more and more scientific and technological research bodies have expanded their own business network and relaxed the control over their staff.

These are the two goals of the reform of the nation's research and development system in order to let most research bodies become able to fund themselves and to raise the society's productivity with their research results.

For these purposes, the State Council stipulated a set of regulations at the beginning of the year.

The present situation is, however, that most scientists and engineers still have little chance to "flow" in one way or another.

Guo Shuyan, vice-minister of State Science and Technology Commission, complained that while various departments under the State Council or the Chinese Academy of Sciences still hold the reins of 1,005 research organizations, accounting for 20 per cent of all the research institutes above the county level. Research workers in these institutes make up 65 per cent of the nation's entire research staff.

Guo pointed out to the magazine Outlook Weekly that among more than 6,000 State-run large and medium-sized industrial enterprises, only 1,900 have established their own research and development centres.

The lack of expertise in rural area is even more serious, he said.

Yet, there has been no sign so far of agreement on how far and free the flow of personnel should become. This seems to be an area where uniform policies do not apply.

For instance, it would be a rather dubious proposal if one suggested that research personnel in the cities should be all dispersed and redistributed evenly to the newly industrialized rural regions.

Only by working together can scientists and engineers prove most creative. The real problem does not seem to be where the research bodies are located, but how society can learn about research achievements quickly and put them into commercial production.

Firms

Certainly, it is good that some scientists and engineers have launched their own business firms. But it is also certain that not all of them can leave their laboratories and become business people.

The kind of mandatory control over the employment of scientists and engineers, in practice from the

1950s through the 70s, also had its merit in strengthening the nation's development.

The administrative departments assigned specialists to where they were most needed, and buttressed up the nation's newly founded nuclear and space industries.

As the economic policies have become more flexible in the 80s, the weaknesses of this kind of planned personnel distribution outweigh its benefits. Nonetheless, this does not prove that the old system should be abolished.

It is therefore expected that the free flow and planned distribution of personnel, as two ways to supply talented manpower to production, will co-exist for quite some time in the future.

At least, all the nation's well-educated people cannot stay in the cities. An optimal pattern of their mobilization is presumably that they will gradually gather in small cities, where they can easily extend their service to the nearby rural areas.

The free flow of manpower will depend on the emergence of a free flow of many goods and services. For instance, research and development institutes, once cut off from State financing, would become crippled if there were no other sources for funding.

Before all that is possible, there are some things that can be done at present. And the scientists and engineers are right now working in these directions.

The employers of scientists are contacting them directly now, instead of through a centralized personnel department. A scientist can now be shifted or borrowed from one workplace to another, or contracted to a position for a certain period of time.

He can also take part in co-operative projects with other organizations and be invited to give lectures or be a part-time researcher.

At the same time, self-sponsored independent academic associations have been set up to help arrange their members' jobs. This can also help curb bureaucracy over personnel affairs.

'Imbalanced' Distribution of Technicians

Beijing CHINA DAILY in English 6 Mar 87 p 2

[Text] China's Northwest which encompasses Shaanxi, Gansu and Qinghai provinces and the Ningxia Hui and Xinjiang Uygur Autonomous Regions, is one of the country's least developed areas. A widely assumed reason for the backwardness is the area's lack of technicians and professionals.

But an investigation by Guangming Daily indicates this is not the case.

According to the results of the study, published last week, professional and technical personnel in the area numbered about 1.1 million in 1985, and 700,000 of them were in the natural sciences.

On average, then, there were 96.5 natural scientists and technicians for every 10,000 residents. This was much higher than the national average in the same year, 74.7 per 10,000.

However, the distribution of the Northwest scientists and technicians was seriously imbalanced: most were concentrated in large, State-owned enterprises and in big cities.

Almost all small and township enterprises suffered from shortages of technicians, while a pool of professionals is idle in the large enterprises and cities.

Thus professional manpower is under used in the big enterprises and cities. Only 20 to 30 per cent of the scientists and technicians in Qinghai and Gansu provinces have full-time jobs that keep them busy all day. It is estimated that another 20 per cent kill their time at work sipping tea. The remainder works only part-time.

Meanwhile, in Northwest township enterprises, technicians

account for only 0.5 per cent of the total employees. The city of Yinchuan, capital of the Ningxia Hui Autonomous Region, has 285 small township enterprises, with fewer than 80 technicians among them.

A second imbalance is in the special fields of the professionals. Of the Northwest's 700,000 natural science professionals in 1985, engineers accounted for 43 per cent, doctors 28 per cent, scientists and research workers 4.6 per cent, teachers 16.7 per cent and agricultural technicians 7.8 per cent.

In Qinghai Province, one of China's cattle-raising centres, there are only 2,500 technicians engaged in animal husbandry, only one for every 15,000 cattle. Many middle schools in the Northwest have given up offering foreign language courses for lack of qualified teachers.

The situation can never be corrected under the present employment system, which treats professionals as the private property of their work units or the units' supervising administration.

Most factory directors prefer to stockpile technicians for "later use" rather than releasing them to township enterprise where they are urgently needed. Since the State will pay for these technicians, what do the factory directors care?

Efforts

Even if factory directors are willing to let their technicians go, the procedure to do so is long-drawn-out. Any personnel transfer to another enterprises has to be approved by the relevant provincial administrations.

Thus most of the efforts of township enterprises to recruit professionals from State-owned enterprises have been rebuffed, despite the fact that many technicians have been willing to be transferred.

The system of allocating college graduates is partially to blame.

Since 1949 graduates have been indiscriminately assigned by the central government to State-owned units, even if these units are over staffed with technicians. Furthermore, there is no supervision to see whether these technicians are given jobs in their fields of training.

In 1985, for instance, the State assigned some 150 normal-college graduates to the State-owned Xinjiang Construction Company. But instead of placing them at the company's schools where they were needed, the company put one-third of them in non-teaching jobs. Chinese-literature majors are now working as bank clerks. Would-be physical-education teachers work in trade unions, and physics graduates are assigned to security departments. Many of the college graduates feel resentful, cheated and misused.

The Northwest's scientists and technicians are urging that the present unit and departmental control of personnel should be revised as soon as possible and that the State should support job changes.

Except in special cases, they say, transfer of technician should be decided through consultation between their original work units and the recruiting party. Provincial departments will have the final say in case of a dispute.

Certain transfers should be promoted, such as sending technical teams to township industries and remote areas. Technicians should be allowed to contract out their services to projects, either collectively or individually.

In the field of animal husbandry, agricultural production and education, special practices should be initiated to attract more professionals — for instance, pay raises and better living conditions and retirement benefits.

Finally, the State should allow technicians to increase their personal income by taking more than one job simultaneously.

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REVIEW, PREVIEW OF HEAT RESISTANT MATERIALS INDUSTRY

Luoyang NAIHUO CAILIAO [HEAT RESISTANT MATERIALS] No 3, Jun 86 pp 1-8

[Article by Tao Ruozhang [7118 5387 3864] of the Coking and Refractory Materials Department of the Office of Steel and Iron of the Ministry of Metallurgy Industry: "Unite and Insist on Reform to Achieve New Victory; A Review of the Recent Development in China's Refractory Materials Industry and Opinions on the Work Planned for 1986"]

[Text] Since the 3d Plenum of the 11th CPC Central Committee, under the guidance of the policy to focus on the domestic economy and to engage in free exchanges with the rest of the world, the Chinese fire resistant materials industry made significant progress in all aspects as a result of the contributions of its more than 100,000 employees. We are in a nice cycle where the value of the products manufactured has increased at a faster rate than the quantity produced and the rate of profitability increase is higher than the rate of increase of product value. It begins to follow the track that production relies on technical advances, exploitation of potential resources, technology reforms and expansions. The industry is entering a new historic era.

I. Brief Review of the Sixth 5-Year Plan Period

A. An industry-wide reorganization resulted in improved quality, steady progress in production and higher profits.

In the Sixth 5-Year Plan, the refractory industry underwent an overall re-organization. After 4 years of hard work, the re-organization of the key metallurgical refractory industry in China has been completed.

The reorganization adjusted the leadership of the industry based on the need to realize the Four Modernizations. The guiding ideology of the industry changed significantly. We began to establish management concepts which coincide with the economic aspects of the products. We are paying attention to market changes and have strengthened our idea on competition. In addition, we focus on the economic and social benefits of the industry to move away from the conventional pure production mode of operation. It is switched to a developmental management mode. As the government investment changed from a grant to a loan, the industry began to learn the concept of investment and

return. Amidst market competition, the industry realizes that its survival and continued growth can only be ensured by the wisdom and creativity of its employees. It hinges on the education and training of talent. Therefore, the concept of information exploitation is reinforced.

Pushed by the reform, the industry widely implemented management by objectives. It established and gradually perfected an economic responsibility system based on various tiers of contracts. The economic benefit of the business is linked to that of the employee. We began to destroy to past situation that "everyone eats out of the same big pot" to motivate individual enthusiasm. In the mean time, we strengthened the basic management, restructured labor organization, tightened the rules and revised the reward and punishment system. In 1984, some key refractory enterprises also tried out a plant manager responsibility system. The Chinese Communist Party leadership was improved to strengthen the democratic management. The industry has been changed by a great deal to serve as the foundation for its future growth. The growth of the steel industry is an important external condition for the growth of the metallurgical refractory materials. In the Sixth 5-Year Plan, the steel production in China grew by 25.8 percent in China. The refractory materials produced in China in 1985 is increased by 48.5 percent as compared to that in 1980. The majority of the key refractory enterprises had record-level production, product value, and profits. In 1985, more than 90 percent of the key refractory enterprises paid more taxes and had higher profits than in 1984. The tax revenue increased at a rate higher than that of the output value, creating another historic high.

B. The industry is given vitality by the reform. It is in the middle of a transition from a closed management to an open one.

According to the spirit of the decision of the Chinese central government on the reform of the economic system, production planning of refractory materials has been gradually changed from a centralized management system to a system that the central government and the local authority are responsible for instructive and directive planning for some products in some enterprises, respectively. As for the allocation of products, with the exception that certain products which are vital and in short supply, such as magnesia bricks and the coke furnace bricks produced by some plants, are still allocated by the government, other refractory products are gradually deregulated and controlled by the market.

As the autonomy of the enterprise expands and the number of government allocated products shrinks, the effect of pricing on the enterprise activity of the refractory industry becomes more obvious. It is an urgent matter to establish a rational pricing system for refractory products. In the Sixth 5-Year Plan, the prices of refractory products were changed twice. The pricing of products was changed from a system that the central government fixed all the prices to a dual price system that the central government and the local authority can fix the prices. The central government determines the prices of products which are widely used and have national or Ministry of Metallurgical Industry standards. In these products, except for magnesia bricks, the government only fixes one brand or a few brands of a specific product (as the base price), products of other brands, highly specialized products with a

narrow market, and products with local (business) standards alone are priced at the local level.

As the production plan and product allocation method were altered, the intensifed effect of merchandise production and value added pressure, vitality and activity to the business. Each enterprise strengthened its efforts in market surveying and forecasting based on local raw materials, energy and transportation conditions. The product line structure is being adjusted with due consideration being given to technical strength, equipment and production experience. In addition, in order to organize the production of products which will sell and to improve the competitiveness of the product, every enterprise built flexible production facilities. A large number of plants (segments) for manufacturing special refractory materials have been built. Their presence relieves the shortage of some goods in certain areas or in the entire country. It also urges the industry to grow by depending on advancing the technology, resulting in the emergence of a number of plants producing specialized products with unique characteristics.

In recent years, a lateral economic link between enterprises is developed. A loosely structured, non-entity type of chain begins to emerge among enterprises using one product as the common link. It breaks area, department and ownership barriers, takes advantages of its own edges, and promotes growth in production. In order to open all avenues for financial resources to invest in technology reform, some enterprises used a domestic/foreign compensation trade scheme.

C. A comprehensive quality management system was implemented to develop "hot selling" products. The product structure of refractory materials is gradually changing.

To strengthen standardization is a prerequisite for improvement of product quality. In the Sixth 5-Year Plan, the standardization of refractory materials was focused on revising the structure of the system and improving the level of standards. Based on the requirements of the Chinese Bureau of Standards and the Ministry of Metallurgical Industry, since 1982, we insisted on the policy of "serious research, active adaptation and differentiating treatment." Based on the current standardization practice in China and the technology and equipment in the industry, a plan to implement international standards and advanced foreign standards was drafted. In the area of basic standards (i.e. product classification, terminology, sample preparation methods and general testing methods), it is equivalent to adopting the international standards (i.e. ISO standards). In terms of production technology standards (i.e. fire resistant raw materials, press-formed refractory products, insulation-formed refractory products, un-formed refractory materials, fire resistant fibers and heat insulating sheets), the Chinese standardization system was formulated by modifying the systems used in Japan, West Germany and the Soviet Union.

In the Sixth 5-Year Plan, the industry widely adopted a three tier system, national standard (universal standard), ministry standard (trade standard) and industry standard (commercial standard for ordering). Many enterprises formulated internal standards to organize and review the production process.

There are 122 standards for refractory materials in China, 84 national standards and 38 ministry standards. Based on the classification of standards, there are 76 basic standards and 46 production technology standards. The dilemma that inconsistencies existed between production technology standards and test methods in the past was preliminarily resolved. A good foundation has been laid to improve the quality of refractory materials.

Quality management was widely implemented through reorganization. A quality assurance system has been set up to continuously perfect the internal standards. It is also linked to the economic responsibility system. The Ministry of Metallurgical Industry conducts an annual inspection on the quality of refractory materials and promptly releases the results. It stimulates quality related activities.

In 1980-1985, 28 refractory products were named high-quality products by the central government or the Ministry of Metallurgical Industry. For instance, the high-alumina bricks made by the Tanggang Refractory Factory, the high-alumina bricks produced by the Angang Refractory Plant for lining the top of an electric furnace, the BG-95 silica bricks made by the Luoyang Refractory Plant to be used in glass kilns, the clay bricks for blast furnace use manufactured by the Shangdong Refractory Factory and the magnesia-alumina bricks for open hearth furnace use manufactured by the Angang Refractory Plant received the silver quality awards from the Chinese government. The physical and chemical specifications of these products have met or are close to the advanced standards set by similar products made abroad. They have demonstrated a steady performance record. They are being produced in large volumes and are being widely distributed with good reputation. In addition, products such as the fire resistant, pre-fabricated plastic brick for heating furnace by the Majiagou Refractory Plant, the large clay brick in glass kilns, the graphite crucible by the Tianjin Refractory Materials Factory, the high-alumina content sliding casting brick by the Shanghai Refractory Plant and the Anshan Iron and Steel Refractory Plant, the heterogeneous clay brick by the Lengshuitan Refractory Plant, and the conventional magnesia brick by the Dashiqiao Refractory Plant are well received by the customers. They become products of preferred brands.

In the Sixth 5-Year Plan, refractory products were driven by the market in the direction of better quality, higher performance, greater variety and series of products. The product line structure is gradually changing.

The social benefit is improved when comparing the productivity of refractory materials in 1984 to that in 1980. High-alumina brick grew by 82.2 percent and magnesia brick increased by 35.4 percent. The energy consumption is lower and the industry adapts well. The use of high performance unshaped refractory materials grew by 42.1 percent. In particular, the market demand for special fire resistant materials went up 5.6-fold.

D. The development of new products and novel technology pushed the refractory materials industry forward.

In order to satisfy the needs of technical advancement in the steel industry and to adapt to market changes, a large number of new refractory materials and technologies were developed in the Sixth 5-Year Plan through technical collaboration, analysis and digestion of foreign technology. In particular, we issued the technical policy and equipment policy for the refractory materials industry to clearly specify the directions of the technical effort in the development of metallurgical refractory materials in China to forcefully promote technological advancement.

The refractory material in a steel converter has been changed from using tar dolomite bricks to magnesia dolomite bricks (roasting into oil-soaked and inflammable bricks). We are scaling up the batch size in manufacturing products such as dolomite carbon bricks, magnesia carbon bricks, and synthetic high calcium magnesia bricks.

Because the quality of the lining of the steel converter was improved, the average life of a converter in China reached 606 runs in 1985, an increase of 8.2 percent as compared to 1980.

The development of a cinder blocker for the converter also achieved significant results.

The development of excellent quality high performance low alloy and alloy steels is also a major technical policy of the Chinese government. China has built a series of refining furnaces of various models such as AOD, VAD, LF, RH and DH. The amount of refined molten steel produced increased by nearly sevenfold in 1985 as compared to 1980. The refractory materials used in the steel refining furnaces primarily include the high quality chromium magnesia brick (including pre-reacted, fused, and synthesized), alumina dolomite brick and magnesia carbon brick. The synthetic magnesia chromium brick was used on the cinder lining of the the VOD furnace. Its life is over 18 runs. The erosion rate is 0.24 - 4.1 mm/run. At a refining temperature of 1670 -1700 C and with cinder alkalinity C/S > 2.5, the average life of the high chromium fused magnesia brick in the VAD furnace is 25 runs. The maximum life is 42 runs. In the VOD furnace, the average life is 20.6 runs.

Injection metallurgy is a new technology. In 1985, the amount of molten steel used in injection metallurgy grew 4.3-fold as compared to 1980. The domestically made injection nozzle was lined with a clay high-alumina brick. It could only be used once. After using the complex structured nozzles in both integral and assembly designs under development on a trial basis on the SL powder jet device in the past two years, the results are found to be satisfactory. The average life of an integral nozzle is 14-17 runs. The industry has already begun batch production of nozzles. The annual capacity is of the order of several thousands. In the past, high-alumina bricks were often used at the cinder line of the powder jet steel container. The life is 2 - 6 runs. The poured periclase-spinel lining developed last year is used in 25-ton powder jet steel containers. Its average life is 2 runs. An integral

nozzle suitable for the pre-desulfurization of molten iron was also successfully developed.

In 1985, the continuous casting of billet and continuous casting ratio grew 1.18-fold and 4.5 percent, respectively, as compared to 1980.

In the Sixth 5-Year Plan, the development of refractory materials for continuous casting moved rapidly forward in China. We developed the submerged quartz taphole technology for melting powders, the alumina-carbon submerged taphole brick, the alumina-carbon integral rod, the zirconium-based composite fixed radius taphole brick (panel type and direct composite type) and the thermal insulation sheet. The use of the submerged powder melting quartz taphole raised its average life from 1.68 to 2.68 runs. The taphole fracture incident rate dropped from 5.48 percent to 1.24 percent. In 1985, a newly developed alumina-carbon based below surface nozzle was used in a continuous sheet casting machine for pouring steel sheets for ship construction. The average life is 6.4 runs and the maximum life is 8 runs. Particularly, the use of an anti-oxidizing coating and a cinder-resistant composite material makes the erosion rate reach the level of 1.25 - 1.38 mm/run. The erosion resistance is improved by onefold as compared to that of similar products made in the past. The use of an alumina-carbon based long and below surface nozzle in a machine for the continuous casting of stainless steel sheets, the rate of erosion at the cinder line is 1.6 - 1.75 mm/run. The taphole fracture rate is 0. It essentially, meets the needs in the continuous casting of specialty steel. The use of a zirconium based fixed radius nozzle for the continuous casting of small square blanks was found to be satisfactory. The pulling rate is steady and the radius expansion is negligible. The use of a heat insulating sheet in continuous casting can eliminate the baking step which saves 0.2 kg of oil per ton of steel. It accelerates the turn around time and minimizes contamination. Silica thermal insulation sheets have been widely used. The products discussed above are already in production in China. The zirconium based fixed radius taphole has already been developed into a series of products.

The BN joint ring developed for continuous horizontal casting has been preliminarily tested. It was used several times to cast 2 tons of steel with a 80 mm diameter die for more than 40 m in length. The working surface was eroded by 0.3 - 0.7 mm. The best record was the casting of 4.5 tons of steel with a 80 mm die for 93.6 m in 53 minutes. The ring remained virtually intact with no cracking and peeling. The hole was not expanded either. The working surface was only eroded by 0.5 mm. It is already in production in small quantities.

The sliding taphole brick for the steel container was further extended in the Sixth 5-Year Plan. It is used in more than 60 percent of the steel casting operations in China. It has been gradually developed from the high alumina content inflammable brick to bricks made of magesia, alumina-magnesia and carbon-alumina. The useful service life is significantly improved. The model 501 alumina-carbon brick has a useful lifetime of 3 runs and a 99.75 percent sliding efficiency. The amount of steel leakage is less than 1/1000. In the past 3 years, the reliability of the slide sheet was improved by referring to the hoop-making experience developed in the world.

In 1985 alumina-carbon bricks were used in the continuous casting of special steel. The average lifetime is 7.3 runs. The maximum is 10 times. The maximum erosion depth on the sliding surface is < 0.3 mm. The erosion rate of the cast hole is 0.2 mm/run which is a new record in China.

In addition, significant progress was made in assimilating imported taphole materials and sliding mechanisms.

The refractory material used in a blast furnace is also changing in China. Because the temperature is very high at the bottom of the furnace, it suffers from serious alkaline corrosion. It generally requires an overhaul in 2 to 3 years. It is a weak link. The recently developed silicon carbide - silicon nitride brick has been tried at the bottom of the blast furnace and the air inlet of the furnace. An emery brick with good high temperature creep resistance is used in hot blast furnaces. The physico-chemical specifications of the material developed are on the same level as the imports.

Based on an analysis of the physico-chemical properties, the phosphate soaked blast furnace clay brick has high resistance against alkali metal attack and carbon precipitation at high temperature. This brick has already been installed in middle and upper parts of blast furnaces on a trial basis.

In the Sixth 5-Year Plan, a great deal of progress was also made in the development of energy conserving, thermal insulating fire resistant materials. Based on the successful development of the conventional aluminum silicate fiber, in recent years, a high purity high aluminum content fire resistant fiber was developed. A colloidal method was developed for making crystalline alumina fiber which brought the fire resistant fiber industry in China into a new era.

Recently a resistance technique was also developed to continuously melt and blow refractory material into fibers. It was continuously in operation for 185 hours. It consumed 2.57 kilowatts per unit of fiber.

In order to accelerate the development of fire resistant fiber technology in China, two fiber production lines were imported in the sixth 5-Year Plan. They have been assembled and put in production. The Ministry of Metallurgical Industry is organizing a team to duplicate the imported equipment.

The current annual production of fire resistant fiber in China is approximately 5,000 tons. it is widely used in industrial furnaces operating below 1000 C. The products come in sheet, blanket, paper and rope forms. Based on the statistics of 15 steel industries including Anshan Iron and Steel works, 54.5 percent of the furnaces are covered by fire resistant fiber. This will save 259,000 tons of standard coal on a cumulative basis.

The trend for thermal insulation fire resistant products of fixed shapes is light weight and high strength. Anshan Steel Research Institute, Fushun Refractory Plant, Weifang Refractory Plant, Henan Pingdingshan Porcelain Plant used coal dust from power plants as the raw material to make a new low thermal

conductivity, high strength brick at a density of 0.4 - 0.5 g/cm^3. It can directly be used as the inner lining of a medium temperature furnace. It is already in the market.

In the Sixth 5-Year Plan, fire resistant materials of undefined shape have evolved from simple casting materials such as fire resistant concrete and plastics to such new products as coatings, sprays, and refractory mud. They are widely used in industrial furnaces in steel mills with satisfactory results.

In addition, the application of refractory materials of undefined shape has been extended to the smelting system, including the high temperature smelting furnace, flow trough and container. In recent years, the popular steel container is made based on an integral construction technique with refractory material of undefined shape. The lifetime of the pail lining is improved by several fold.

Steel fiber reinforced casting materials have already been used in injection metallurgy and in the desulfurization nozzle for molten iron. A porous grog based thermal insulating casting material is also being applied.

The JT high temperature coating has several advantages including a high thermal radiation intensity and ease of application. It can be used in 1400 C industrial furnaces if it does not come in direct contact with the cinder. It can conserve 3 - 15 percent of energy. This coating is being used in 85 organizations in China within the steel, non-ferrous, machinery and chemical engineering systems.

In the Sixth 5-Year Plan, new progress was made in the development of refractory slurry. Based on analyzing imported fire resistant slurries, a silicon slurry for coke ovens, a buffer slurry with asbestos fibers, a high aluminum content slurry for blast furnaces, sintering ovens, and torpedo vehicles, a thermal insulation slurry and a clay slurry were developed. We are conducting research to develop a series of refractory slurries to meet the specific needs in China based on the resources available. We will gradually change the "fire mud" concept (grinding of rejected product). This is especially meaningful in overcoming the weakness at the seams between bricks to lengthen the lifetime of the structure.

Regarding Equipment for Refractory Materials:

Most of the brick presses used to produce refractory materials in China today are direct contact driven friction units. In order to improve the quality of the bricks and safety in operation, the Northwest Refractory Materials Plant and Jiaotong University at Xian successfully developed a 160 ton electromagnetic spiral brick press. It is safe and conserves energy. This is a promising piece of forming equipment. It is already in production at the Northwest Refractory Materials Plant. We are developing a 300 ton brick press as well. The 800 ton hydraulic press has met certain standards in hydraulic technology and automation. In addition, domestically developed large static pressure forming machines are used to manufacture refractory materials of various odd shapes. They are stable and reliable.

The photoelectric safety device for brick presses, which was jointly developed by the Majiagu Refractory Plant and Tainjin Automation Component Plant, has also met the necessary standards. It is also in production.

In the Sixth 5-Year Plan, China also developed the continuous melting and blowing resistance furnace for refractory fibers, the Model QH heavy duty reverse flow mixer, and the Planet model forced mixer. We also designed a high temperature vertical furnace capable of smelting at 1800 C and a 1700 C high temperature tunnel furnace. These high temperature furnaces are being perfected.

In addition, progress was made in the one-step smelting of magnesia dolomite, the refractory tunnel furnace technology, the magnesia-carbon brick, and bonding agent for refractory materials of undefined shape. Some accomplishments have already been applied in production or converted into productivity.

In the Sixth 5-Year Plan, the government invested in two pilot plants (shops) for refractory materials. Their mission is to develop high quality new refractory materials to meet the needs in out of furnace refining, large size high temperature blast furnace, thermal storage room of glass furnace and other high temperature technologies. Furthermore, they can provide technical parameters such as the process flow and equipment design for the production of these refractory materials. The pilot plant for magnesium-based refractory materials is primarily responsible for the development of magnesium-based fire resistant materials, including the pilot testing of the manufacturing technique and the equipment. The completion of these pilot plants will accelerate the development process of high quality refractory materials in China.

E. Success in Energy Conservation

Through reorganization, every unit has tightened its control on energy. A healthy energy management organization and system was established to continuously perfect the inspection and testing methods.

Based on statistics compiled at 11 key refractory plants in Luoyang, Shandong, Shanghai and Majiagu in 1985, the total amount of refractory materials produced is 968,000 tons. The total worth is 199 million yuan. The total energy consumed is 314,000 tons of standard coal. The overall product unit consumed 325 kg of standard coal. Each 10,000 yuan worth of products consumed 15,830 tons of standard coal. The overall energy consumed per ton of bricks is 422 kg of standard coal, which is a 38 percent decline as compared to the 681 kg in 1981. The energy consumption in production processes for silica brick, magnesia brick and high alumina brick has met the highest energy conservation standard set by the Ministry of Metallurgical Industry.

6. Problems and Gaps

Although the refractory materials industry in China has a number of key personnel with some production experience and the industry has developed some new products for the steel industry and other industries, the status of the industry does not suit the needs of the steel industry and other industries. It is quite far behind that of developed nations.

Since the oil crisis in the 1970's, developed nations in the world began to strategically adjust their technology structure. Especially under the impact of the current new industrial revolution, this process is significantly accelerated, which put the refractory industry into a new development stage as well. The development trend can be characterized by energy conservation, less labor, more varieties, high quality, high product value and low volume. It gradually moves from labor intensive products to technology intensive products.

In the Sixth 5-Year Plan, China's refractory materials industry was essentially fighting with numbers. The profitability in most enterprises improved because of increased volume of production. The production volume of refractory materials grew rapidly with the volume of steel produced. It even exceeded the rate of steel production. The consumption of refractory materials for steelmaking was too high. It has a serious social benefit problem.

Poor quality and little variety were important reasons why the volume of refractory materials produced in China increased substantially in the Sixth 5-Year Plan.

Variety and quality are closely related. It actually reflects the technological level of the products and indicates whether the products meet the needs of the society.

The "high volume" based product structure of the industry essentially remains unchanged. The prominent problems in quality and variety are the following:

1. Most of the new products developed in the Sixth 5-Year Plan have not been put in production yet. Many products are in a pilot production stage. For example, the aluminum-carbon slide plate developed in the Sixth 5-Year Plan is an urgently needed refractory material in continuous casting. To date, no production facility to meet the needs in the country has been built. In other countries, higher quality refractory materials such as corundum brick and silicon nitride - silicon carbide brick are being used more to improve the life of blast furnaces and to avoid overhauls. These products are essentially not available in China.

2. The quality of the products is not high. Some individual major products show a downward trend in quality. Especially with products in great demand, the phenomenon that "mud is not washed of the reddish when it hits the market." For instance, in a quality inspection of key products in China, four out of six technical indicators of the high alumina brick for electric furnaces produced by a plant did not meet specifications. Spigots for steel

containers, tapholes and slide plates are essential materials for steel casting. Due to poor quality and lack of care in use, steel leakage incidents happen frequently. In some plants, the quartz conversion in the silicon brick for coke ovens is poorly done because the temperature treatment period is too short. The residual quartz contents reaches as high as 20 percent. Its appearance is also undesirable. This directly affects the quality of the coke oven. Although the economic benefit of the refractory industry has been rising the recent years, however, due to the low base index, the average profit per capita is falling behind other industries by a large margin. The industry has very little ability to improve itself. The technology advances at a very slow pace. To this end, in the Seventh 5-Year Plan, the refractory industry must push for technology reform in steps based on rebuilding old plants to develop production techniques and product series to meet the domestic needs. A supply and manufacturing system for the refractory products will be gradually completed to aid the steel industry and other industries.

II. Work Arrangements for 1986

1986 is the first year of the Seventh 5-Year Plan. A new era for the refractory industry has begun. We must further perfect reform work, strengthen enterprise management, improve profitability, and continue building up our capability for self-development. In manufacturing technology, we must focus our attention on quality and variety, instead of quantity. We should insist on developing high quality, efficient models to gradually develop a variety of series of products. We must insist on putting our emphasis on an open system, instead of a closed system in order to develop a lateral economic link with others. We have to carry out technology reform in steps to push it forward. In managing product flow, we must establish the concept of the market and competition in the market. The refractory industry in China is going to be built as a production and supply system for a variety of levels of products to better serve the users.

In switching from a quantity oriented to a quality and variety oriented industry, we must first look at the needs in the development in steel industry. In summary, we must concentrate our efforts on the development of refractory materials in the five areas to be developed by the steel industry; those being: the development of energy saving, thermal insulating materials for the top and bottom blown converters and high tension electric furnace, continuous casting, refining outside the furnace, large blast furnaces, and high temperature blast furnaces and large coke furnaces. We must succeed in the construction of the 10 production lines; i.e. magnesia-carbon brick (including magnesia-dolomite-carbon brick), high quality magnesia-chromite brick, high quality sliding cast taphole brick, gas permeable brick and gas supply brick, below surface nozzle, zirconium-based fixed diameter taphole, sandwiched heat insulating sheet, high quality silicon brick for coke furnace, high quality alumina brick, corundum brick, silicon nitride/silicon carbide brick, refractory materials of undefined form (including refractory mud), energy saving fire resistant materials (fire resistant fibers and thermal insulating bricks), and high quality synthetic refractory materials.

A multi-level production and supply system will be built for refractory products.

First level: Using the 10 production lines as its focal points, it will supply the whole nation with high and medium quality products.

Second level: The objective is to meet the needs of local industries. Based on the resources available in the area (such as raw material, energy, transportation, etc.) it will develop the appropriate products for the local market to complement the high and medium quality refractory products.

Third level: Its primary function is to regulate the market. It will supply common refractory materials to the marketplace.

In the first and second levels of the structure, production must be specialized through cooperation, offering a complete line of products. Plants producing special products must be constructed. These units are the backbone refractory enterprises on the ministry and local level (including secondary refractory plants affiliated with the steel industry). They must full utilize their advantage in equipment and technology to make a strategic transition toward the manufacture of high technology (or information intensive) products.

The third level in this structure primarily consists of local small enterprises (including town and village owned enterprises). They were created by demand and are very active.

The refractory industry must closely coordinate with the metallurgical industry to meet the goals and requirements set in the workshop for 1986.

A. Strengthen Management and Complete Internal Reorganization

In terms of the ideology, the industry must switch from a product-based economy to a commodity-based economy. It will have to grasp a whole series of steps in the commercialization of a product, including market projection, capital financing, new product development, manufacturing, sales, and service. It must produce products that will sell in a timely fashion to improve its competitiveness.

Fundamental management of the industry must be strengthened by starting with measuring standards, setting quotas, establishing regulations, offering employee basic education and building files to combine the basic functions of the enterprise with scientific management. The experience of using microcomputers in management will be summarized continuously in order to explore the possibility of using it in process control.

The internal economic responsibility system must be reinforced and perfected. The concept of overall profit of the enterprise and its social benefit must be established to avoid a segmented contracting phenomenon. We have to notice that quality, product variety and safety are often compromised in a contract in order to raise quantity and profit.

B. Arrange the First Batch of Ministry Projects in the Seventh 5-Year Plan

The key refractory materials for the second stage construction of the Boashan Steel Plant include: silica bricks for blast furnace and sintering ovens, stove, high quality dolomite brick, below surface nozzles for continuous casting for the Boashan Plant which is also urgently needed in steel casting in China, and high quality magnesia-carbon brick for converters with blowers from the top and the bottom.

Projects related to the construction and production of products the Baoshan Steel Mill must be put under control. We must seriously prepare for these projects, particularly preparing a plan with a balanced schedule. We have to check the schedule and cooperate closely to finish the assigned tasks. Organizations that are going to supply refractory materials to the Baoshan Steel Mill must seriously check their work to secure their production resources. They have to deliver on time according to quantity and quality specified in order to minimize the import of refractory materials.

Some preliminary preparation work must be handled well.

C. Quality-related Work

1. Standardization

Based on the refractory materials development plan set by the ministry for the Seventh 5-Year Plan and the existing standards, the ministry intends to call a meeting to discuss the modification and formulation of standards. Standards must be rigorously controlled. Every enterprise must seriously implement product technology standards (national, ministry, local or industry standards). From the date a standard becomes effective, the old standard must not be used again. Starting in 1986, we will change certain ways standards were set in the past. In addition to accumulating sufficient production data, we will do some technology proof work and conduct certain experiments to make the standards more practical.

2. Product Quality Inspection

a. The supervision of the quality inspection work in the enterprise must be separated from production.

b. Random Product Quality Check. In 1986, the ministry will organize either by region (through province, city, department, bureau) or by product similarity (silica brick, thermal insulating brick technical cooperation group) unscheduled random inspections of the quality of refractory products at the manufacturing plants and the principal users. It will issue reports to reveal its findings.

c. We will continue a nationwide annual quality inspection and select quality products at the ministry level.

d. The enterprise with products already chosen by the government or the ministry as high quality products must routinely repeat the inspection work. Local authorities are requested to assist in this work.

3. Establish a National Quality Inspection Center for Refractory Materials.

Based on the requirements set by the National Bureau of Standards concerning the establishment of a product quality inspection center on the national level, it is proposed that such a center for refractory materials based on the resources be established at the Luoyang Institute of Refractory Materials. The center will gradually conduct quality inspection, evaluation and arbitration. It will also issue product permits under the authority granted by the ministry. In addition, it will organize technology review and investigate standard testing methods.

4. Strengthen Lateral Economic Ties to Develop Franchise Type of Operation.

It has been proven that various restrictions must be lifted in order to accelerate the development in the refractory materials industry in China. In the Sixth 5-Year Plan, many refractory enterprises were engaged in joint operations based on products to "supplement others shortcomings with ones strength" to fully utilize the advantages. Production was stimulated and profits improved. Some enterprises adopted a compensation method: the investors receive the benefits. They were able to raise funds to speed up the pace of the reform. Some of the experience is worthwhile referring to. The ministry plan to choose a typical model and call a meeting to exchange this experience in order to push this process forward.

5. Hold Economic Benefit Analysis Activities; Fortify and Perfect Distribution and Pricing System for Refractory Materials

With the exception of a few enterprises, most industries implemented the second tax reform step. In the meantime, they are facing the fact that some raw materials are going up in price. This makes it even more urgent to have an economic benefit analysis for these enterprises.

Specifically in response to the policy issued last year that some product prices are fixed by the government and some are left open for the local (enterprise) to set their own prices, each enterprise must prudently regulate their prices based on the policies set by the central government to avoid confusion. Together with the economic analysis, the ministry plans to organize a study on the economic policy regarding the refractory materials industry in China in order to strengthen the ability of the industry to grow by itself.

6. Energy Conservation

a. Implement the "Temporary Regulation on the Management of Energy Conservation" issued by the State Council to allow the energy conservation work to be placed under control. Each unit must analyze the gap between energy conservation management and its potential capability.

b. Accelerate the adoption of energy saving technology by relying on technical advancement. Many new energy saving products and technologies were developed in the Sixth 5-Year Plan. Every unit must actively adopt them based on its own situation and resources.

c. Launch a campaign to reach objectives by different levels to break the record by learning from the advanced. Based on the furnace used, the ministry is setting new standards for energy consumption. Each outfit must seriously formulate its own plan to achieve different objectives at different levels. The Ministry of Metallurgical Industry will periodically report the objectives met by various key industries.

d. Control every energy saving steps in the process, especially the energy saving step in the furnace. The regional leaders in charge of testing the heating balance in furnaces must strengthen their coordination to handle this project well.

7. Technical Information Exchange and Personnel Training

a. All relevant units must collaborate in the publication of journals such as NAIHUO CAILIAO [HEAT RESISTANT MATERIAL] and GUOWEI NAIHUO CAILIAO [FOREIGN HEAT RESISTANT MATERIAL], and trade news such as NAIHUO XINXI [HEAT RESISTANT INFORMATION] and NAIHUO CAILIAO QIYE SHIXIANG JISHU ZHIBIAO JINGCAI [COMPETITION IN TEN TECHNICAL SPECIFICATIONS IN THE REFRACTORY INDUSTRY]. We must do a good job in running the foundation for publishing technical information on refractory materials. Units with the required resources may publish their own internal journals and promote the exchange of technical information between enterprises.

b. Technical exchanges with other countries must be intensified.

c. All local enterprises must strengthen the training of employees in cultural and professional knowledge based on the resources available. The knowledge of the leadership must also be refreshed. Trade institutes must create the training environment for various enterprises. We must assist the industry to find a link with different universities in order to train engineers in refractory materials.

With the joint effort of over 100,000 workers in the metallurgical refractory materials industry, we have already accomplished a great deal in the Sixth 5-Year Plan which is entered in the history of the development of refractory materials in China.

This year is the beginning of the Seventh 5-Year Plan. More difficult tasks are ahead of us. Under the guidance of the line of the Chinese Communist Party, let us unite and fight. Let us insist on reform and take real actions to win new victories and to make new contributions.

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BRIEFS

ASTRONAUTICS MINISTER OUTLINES TASKS--The tasks of China's astronautics industry from now until the early 21st century are to continue its position as one of the forerunners in world astronautics technology, produce products for the modernization drive, supply quality technical services to the national economy, and market Chinese-made aerospace products in the world, said Astronautics Minister Li Xue at a meeting today. He said: In the next few years, we shall study and develop new rockets for carrying advanced artificial satellites, such as meteorological, resources, and large telecommunications satellites. Expressing optimism for marketing China's astronautics products in the world, the minister said: Since last year, Swedish and U.S. firms have signed contracts to buy six satellites from China's Changcheng Industrial Company. Two U.S. firms, (Troy) and (Panam), have signed a formal contract to launch the first telecommunications satellites for them between February and May 1988. From now on, we shall develop new rockets with a greater carrying capacity, as well as sign more business contracts with foreign firms, said the minister. [Text] [Beijing Domestic Service in Mandarin 1030 GMT 14 Mar 87 OW] /12858

BOEING TO SUBJECT YUN-7 MODEL TO TESTING--A small collective factory under the Xi'an Aircraft Manufacturing Company has made China's first large metal model of an aircraft, thus saving over $1.9 million for the state. To improve the technical performance of the Chinese-made Yun-7 aircraft, the Ministry of Aviation Industry made an agreement with America's Boeing Aircraft Company for providing help in conducting wind tunnel tests on the aircraft. This kind of test requires a large metal model of the aircraft. The American side wanted $2 million to make this model. The Ministry of Aviation Industry decided that the model would be made by the Xi'an Aircraft Company. This task was taken on by the precision casting factory under the Xi'an Aircraft Company. It is a small collective factory which is composed of disabled persons and young people awaiting job assignments. They overcame one difficulty after another and spent just 3 months and 250,000 yuan on making the large metal model of the aircraft, which meets the designer's demands, thus saving $1.9 million. Representatives of the American side have expressed satisfaction with the completed model. This large metal model of the aircraft will soon be transported to the Boeing Aircraft Company in Seattle, in the United States. [Text] [Xi'an Shaanxi Provincial Service in Mandarin 0030 GMT 25 Mar 87 HK] /12858

CSO: 4008/2095

CHARACTERISTICS OF OPTOGALVANIC SPECTRUM IN DISCHARGE PLASMA OSCILLATION

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[Article by Gui Zhenxing [2981 2182 5281], Wang Yumin [3769 5940 3046], Zhang Shunyi [1728 7311 1837], Shen Guirong [3088 2710 2837], Fang Xuewin [2455 1331 0207], and Wang Runwen [3769 3387 2429] of the Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences; paper received 23 September 1985; first paragraph is source-supplied abstract]

[Text] Abstract: Features of the optogalvanic spectrum in He-Ne discharge plasma oscillation are investigated experimentally. The plasma oscillation frequency spectrum is measured by means of optogalvanic effects (OGE).

In low pressure glow discharge, there are present various kinds of oscillatory phenomena of which walking striations is one with a frequency of 10^3~10^5 Hz. There have been detailed accounts concerning the features of this phenomenon.[1] Its appearance in gas lasers can produce noise, so clarifying the mechanism and conditions of its appearance as well as overcoming it is a great necessity.

The oscillatory movement of charged particles (electrons and ions) in plasmas clearly will increase the optogalvanic signal. Study of He-Ne mixed gas lasers has revealed that when the excited plasma oscillation frequency and the plasma self excited oscillation frequency are the same, steep peak signals appear in the optogalvanic spectrum. This indicates that the optogalvanic spectrum can act as a sensitive and convenient means to detect plasma oscillation.

I. Experimental Apparatus

The experimental apparatus is shown in Figure 1. After the selected branch CO laser beam (wave length tuning range of 5.3~6.3 μm) has been chopped to a 1 kHz optical signal by the chopper, via a diaphragm it passes through a water cooled discharge tube with an inner diameter of ϕ5 mm. The length of the discharge tube is variable at 80, 150, or 210 mm and is full of a mixture of helium and nitrogen.

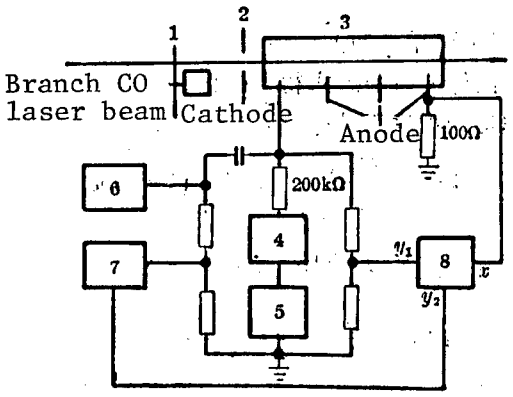

Figure 1. Experimental Apparatus

1--Chopper (f = 1 kHz); 2--Diaphragm (ϕ4); 3--Discharge tube; 4--Direct current source; 5--XD7 low frequency signal generator; 6--Oscilloscope; 7--Frequency-selecting amplifier (f = 1 kHz); 8--x-y plotter

In the experiment, the audio signal is provided by a XD7 low frequency signal generator (power <4 W) and through a 600 Ω resister in series enters the direct current discharge circuit. The discharge limiting current resistance is 200 kΩ. The voltage modulation amplitude is of the magnitude of several volts.

When the spectral line of the selected branch laser induces the discharge media to produce near resonance transitions it induces an optogalvanic voltage signal ΔV. This is read by the frequency-selecting amplifier and input to the x-y plotter. An oscilloscope is used to detect the frequency and amplitude of the discharging plasma oscillation.

II. Optogalvanic Spectral Features of the Plasma Oscillation

First we examined conditions for producing plasma self exciting oscillation for a pure gas discharge situation with the results shown in Figure 2 and Figure 3. From the figures we see that the region of discharging plasma self exciting oscillation (meaning the current range) was reduced with rising pressure and longer discharge distance. After a fixed pressure, the self excitation oscillation region was eliminated. These results are the same as those of reference [2].

If in a situation where self excitation oscillation appears in the plasma, you inject a CO selected branch laser and measure the optogalvanic spectrum signal, the gradients and discontinuities of the signal can be observed. When changing the discharge current making plasma oscillation region, going from a single frequency region to a multiple frequency region, the optogalvanic signal also will show a discontinuity. A typical experimental result of this phenomena is seen in Figure 4. The figure also gives the corresponding discharge voltage-current curve (upper part), the self excitation oscillation frequency (meaning the main frequency), and the

relationship of amplitude according to discharge current variation (lower part). Figure 5 is the self excitation oscillation wave form of different frequency spectra regions.

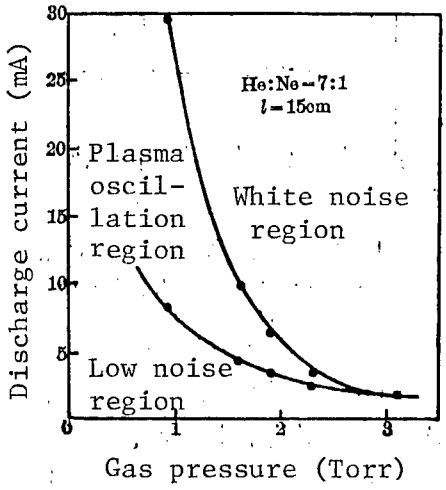

Figure 2. Effect of Pressure on the Plasma Oscillation Region

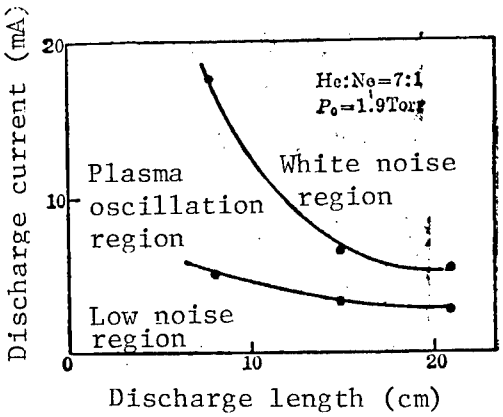

Figure 3. Relationship of the Plasma Oscillation Region to Discharge Length

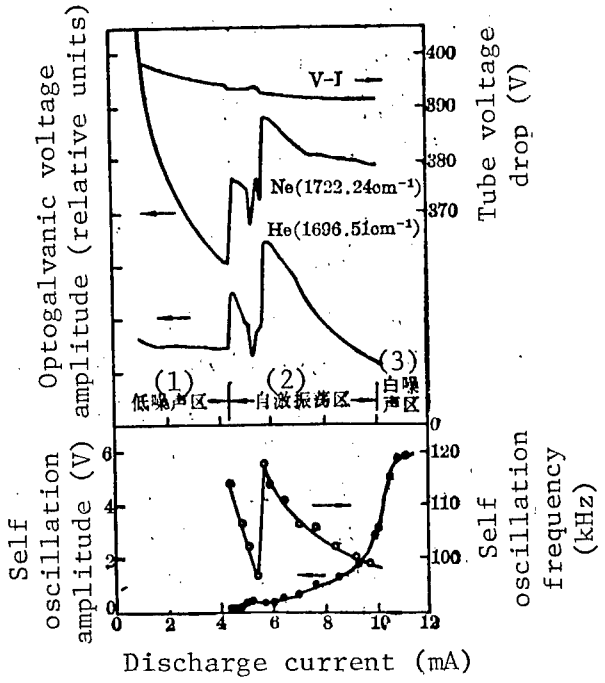

Figure 4. Influence of Plasma Self Excitation Oscillation on OGE (He:Ne = 7:1, P_0 = 1.6 Torr, l = 150 mm)

Key:
1. Low noise
2. Self oscillation
3. White noise

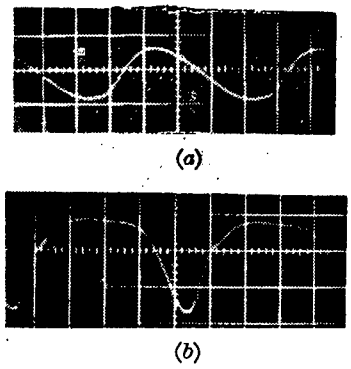

Figure 5. Self Excitation Oscillation Wave Form
(a) i_0 = 4.4 mA, (b) i_0 = 6.5 mA
(Time standard: 2 μs/cm)

From Figure 4 we can see that a discontinuity appears in the optogalvanic voltage signal just as self excited oscillation occurs when the discharge is at 4 mA. Varying the discharge current and sweeping through the self excitation oscillation region, the optogalvanic voltage again shows a discontinuity. Of special note is that at places the optogalvanic voltage is discontinuous, the discharge tube voltage drop also falls suddenly and the discharge internal resistance is reduced. This shows that the plasma oscillation has a severe influence on the discharge state and the optogalvanic effect.

As for the operating mechanism of how plasma oscillation increases the optogalvanic effect, we believe that this is because when the plasma ions manifest oscillation, the charged electron and ion collective oscillates and moves, especially with the electron oscillation frequency ω_{ep} much higher than the ion oscillation frequency ω_{ip}, making the gas polarity increase, manifesting macroscopic ion strengthening effects. Consequently this changes the ion efficiency η_i and forms a nonlinear negative resistance phenomena making the dynamic impedance dV/di drop. From infrared optogalvanic effects of the discontinuities of an inert gas in a highly excited state we know:

$$\Delta V = CK_i\eta_i I \frac{dV/di}{1+(dV/di)/Z} \tag{1}$$

in which C is a constant, I is incident light intensity, K_i is the absorption coefficient, η_i is the ion efficiency, and dV/di is the dynamic impedance. In the current variation range of the discharge oscillation region, C and K_i both are nearly constant. When the self excitation appears it causes the gas η_i to increase and the dynamic negative resistance $|dV/di|$ suddenly changes (this result can be obtained from the discharge V-I curve). Thereupon it makes ΔV sharply increase manifesting optogalvanic voltage signal jump phenomena. Conversely, when η_i reduces, the tube voltage drop increases and ΔV is less.

We studied the effect of discharge self excitation oscillation and external excitation oscillation on the light intensity output (632.8 nm) from a He-Ne

laser and discovered that the oscillations could not increase or decrease the output laser light intensity. This showed that discharge oscillation only changed the charge density and distribution of the plasma and did not obviously effect the absorption coefficient K_i of the energy level discontinuities. Consequently there is no relationship between self excitation oscillation optogalvanic effects and energy levels at which discontinuities occur.

When the electrical source uses audio frequency signal modulation, under fixed discharge current and signal source output amplitude, by tuning the frequency of the audio signal there is observed a relationship where the optogalvanic voltage signal varies with the external frequency which can give a series of steep optogalvanic peaks. Typical results are shown in Figure 6. In the figure, (a) is the result with the discharge at no self excitation oscillation and (b) is the result when there is self excitation oscillation in the discharge itself and its primary frequency is 108 kHz. It is evident that only when the external signal is at a specific frequency does it influence the optogalvanic signal. When the frequency equals the self excitation oscillation frequency, the optogalvanic voltage amplitude attains a maximum several times that without applying an external signal. But the external signal also can make the optogalvanic voltage signal fall to nearly zero. The frequency at which this happens is often slightly larger than the resonance frequency. This is perhaps due to the external signal disturbing the oscillation of the plasma.

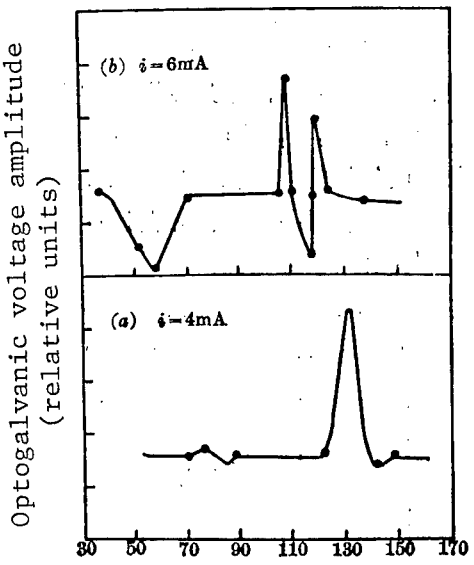

Figure 6. Variation of the Optogalvanic Voltage With Increased Signal Frequency (a) Without self oscillation; (b) With self oscillation (f = 108 kHz) (He:Ne = 7.1, P_0 = 1.6 Torr, near the resonance discontinuity Ne 1722.24 cm^{-1})

From Figure 6 we can see that at a specific current, the oscillation frequency of the external excitation can lead to more than a single optogalvanic peak. Moreover as the discharge current increases, it causes the optogalvanic resonance frequency peaks of the plasma also to increase. This is clearly due to the frequency spectrum distribution of the self excited oscillation being broader after the discharge current is increased.

With a fixed externally applied signal frequency, by changing the voltage amplitude one observes that it has a very great effect on the optogalvanic voltage as shown in Figure 7. The voltages in the figure are the amplitude of the externally applied signal from the two ends of the discharge tube as measured by an oscilloscope. It is evident that when the signal voltage amplitude of the externally excited audio frequency is increased, the range of motion of the optogalvanic wave is increased. Moreover the location of the peak value currents also moved and were larger.

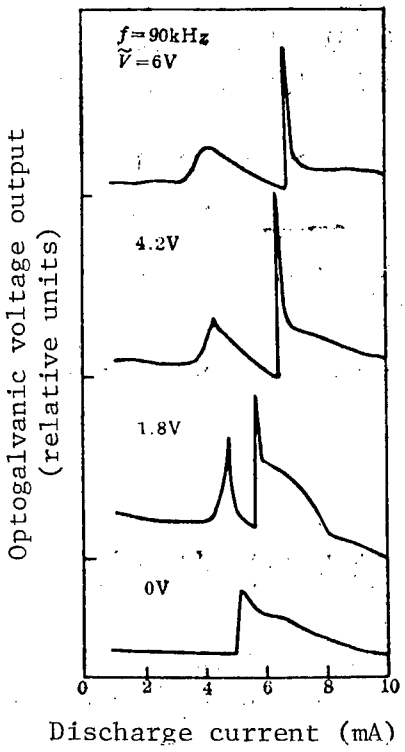

Figure 7. Effect of the Size of an Externally Applied Signal on Optogalvanic Voltage
(He:Ne = 7:1, P_0 = 2.0 Torr, near the resonance discontinuity Ne 1722.24 cm^{-1})

The above experimental results show that when an externally applied signal frequency equals the self excitation oscillation frequency, there is a resonance which appears between it and the discharging plasma. This will sweep the ions of the gas and lead to a clear increase in the optogalvanic voltage. Consequently, based on the peak position of the optogalvanic

voltage there is a possibility we can measure the plasma resonance frequency and study its frequency spectrum features.

III. Measurement of Discharging Plasma Resonance Frequencies

We used a Ne (1722.24 cm^{-1}) optogalvanic voltage signal and externally applied a small signal voltage (about 2 V). Point by point changing its frequency and gradually adjusting the discharge current we recorded a set of curves of optogalvanic voltage versus current change. Partial representative results are provided in Figure 8 and are summarized in the following points.

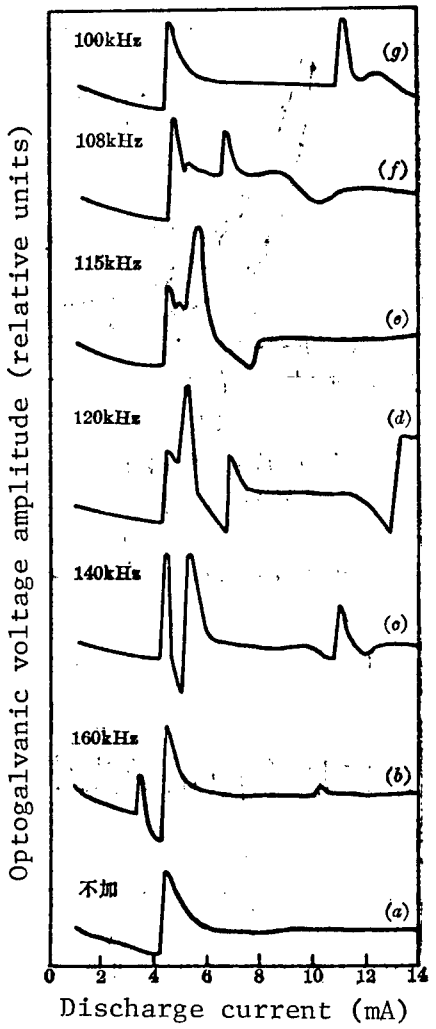

Figure 8. Variation of Optogalvanic Voltage Versus Discharge Current for Different Externally Applied Frequencies (He:Ne = 7:1, P_0 = 1.6 Torr, l = 80 mm)

A. Before the plasma self excitation oscillation region (that is the low noise region), all of them had present a resonance frequency only it was not sufficient for self oscillation. See Figure 8 (b).

B. At the same frequency there could be resonance peaks at several places at which there were strong OGE and weak OGE as in Figure 8 (e) and (d).

C. At a fixed current there also could be several resonance frequencies present. See Figure 8 (d), (e), and (f).

Based on scanning the OGE peaks in the curves and the concavity positions we can get the relationship of resonance frequency versus discharge current as shown in Figure 9. Figure 9 also gives the measured value of the self excitation oscillation primary frequency.

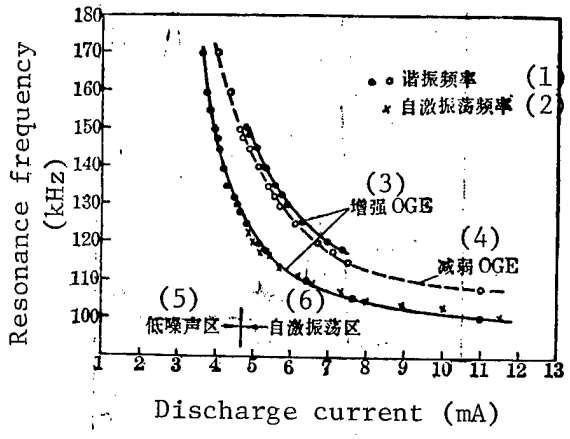

Figure 9. Measured Results of a Discharging Plasma That Has an Oscillation Frequency

Key:

1. Resonance frequencies
2. Self excitation oscillation frequencies
3. Strong OGE
4. Weak OGE
5. Low noise
6. Self excitation oscillation

From this we see that using the resonance optogalvanic method to measure the frequency spectrum features of discharging plasmas has its unique advantages. Besides being able to measure definite oscillation frequencies in the low noise region, it is able to observe the contribution of the various frequency components to the plasma discharge state and the OGE which is something that cannot be matched using a frequency spectrometer. Consequently, this method can serve as a supplemental means to study plasma oscillation characteristics.

Finally, it needs to be pointed out that using the resonance optogalvanic method strengthens this single feature of OGE which has practical significance for the sensitivity of detecting optogalvanic signals.

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EXPERIMENTAL STUDY OF EFFECT OF AXIAL MAGNETIC FIELD IN FREE-ELECTRON LASERS

Shanghai ZHONGGUO JIGUANG [CHINESE JOURNAL OF LASERS] in Chinese Vol 14, No 1, 20 Jan 87 pp 27-30

[Article by Chu Cheng [5969 2052], Shi Ruigen [2457 3843 2704], Lu Zaitong [7120 6528 6639], Zhuang Guoliang [8369 0948 5328], Zhang Lifen [1728 4539 5358], Hu Yu [5170 3558], and Shi Jinchuan [2457 3160 1557] of the Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences; paper received 24 October 1985; first paragraph is source-supplied abstract]

[Text] Abstract: From the two considerations of restricting high energy electron beams and cyclotron resonance to increase laser gain we determined the operating parameters of the axial guiding magnetic field for a Raman free-electron laser and performed some experimental tests.

I. Introduction

We constructed a free-electron laser based on stimulated Raman scattering,[1] obtaining K_a band pulse output and did preliminary parameter study.

This paper discusses the application of axial guiding magnetic fields in the two areas of restricting high energy electron beams and for magnetic resonance strengthening of laser gain. We introduce high energy magnetic field test results and study of related laser preliminary parameters.

II. Determination of the Primary Parameters of an Axial Guiding Magnetic Field

Considering a solid core electron beam in a vacuum (Figure 1), if there is no axial guiding magnetic field B_0, then the radial outward repulsion, eE_r, caused by the spatially charged electric field is always larger than the pinching force, $e\beta_z B_e$, caused by the electron beam's self magnetic field, B_θ,

$$e(E_r-\beta_z B_\theta)=\frac{\omega_p^2 r_b}{2\gamma_z^3}>0 \tag{1}$$

in which $\omega_p\equiv\sqrt{\frac{4\pi ne^2}{m}}$ is the plasma frequency, n is the spatial electron density, e is the electron charge, m is the electron rest mass; r_b is the

electron beam radius; and $\gamma_z \equiv 1/\sqrt{1-\beta_z^2}$, $\beta_z \equiv v_z/c$, v_z is the axial velocity of the electrons.

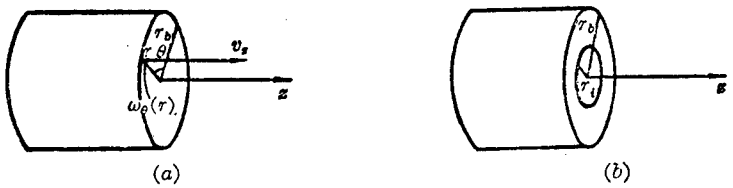

Figure 1. Solid Core (a) and Annular (b) Cylindrical Electron Beam and Their Cylindrical Coordinates

It is evident that to get the collimated electron beam one must apply the axial restraining magnetic field B_0. In the field coupling of Figure 1, supposing the electron density, n, and electron axial velocity, v_z, are fixed values and v_s is much greater than the circular velocity $\omega_\theta \cdot r$, that is $\gamma_z \doteq \gamma$, then the centrifugal force $\gamma\omega_\theta^2(r)$ and the static coulomb force $1/2\omega_p^2$ must be in equilibrium with the axial magnetic restraining force, $\omega_\theta \cdot \Omega$ (in which $\Omega = eB_0/mc$), and the beam self magnetic field restraining force $\frac{1}{2}\beta_z^2\omega_p^2$:

$$\gamma\omega_\theta^2(r) + \frac{1}{2}\omega_p^2 = \omega_\theta\Omega + \frac{1}{2}\beta_z^2\omega_p^2 \tag{2}$$

From this it is easy to see that the rotational frequency of the electrons at various places is equal to:

$$\omega_\theta = \frac{\Omega}{2\gamma}\left(1 \pm \sqrt{1 - \frac{2\omega_p^2}{\gamma\Omega^2}}\right) \tag{3}$$

Clearly, to get an electron beam with electromagnetic forces in equilibrium (that is to make formula (3) have meaning) we must have $2\omega_p^2 < \gamma\Omega^2$, that is the axial magnetic field B_0 must be greater than the marginal value B_{cr}

$$B_{cr} = \left(\frac{8\pi jmc}{e\beta_z\gamma}\right)^{1/2} \tag{4}$$

in which the units of B_{cr} are Gauss and j is the electron beam density (static electric charge/$cm^2 \cdot s$). Under our conditions (γ = 2)

$$B_{cr} = 1.55\sqrt{j} \tag{4}'$$

in which the units of B_{cr} are changed to kG and j is kA/cm^2.

Letting the beam cross section diameter be 6 mm and the beam current be 1 kA, from (4)' we know that the marginal magnetic field required for beam stability is 2.91 kG.

For an annular electron beam a similar analysis showed that the minimum marginal magnetic field value, B_{cr}, to achieve electromagnetic force equilibrium of the electrons at various places within the beam is

$$B'_{cr} = B_{cr} \cdot \sqrt{1 - \left(\frac{r_i}{r_b}\right)^2} \tag{5}$$

in which B_{cr} is defined from formula (4), and r_i, r_b respectively are the inner and outer diameter of the annular beam. It is not difficult to see from formula (5) that when the beam becomes thin and presses up to the wall, the critical magnetic field of the annular beam will be greatly reduced.

Letting $\gamma = 2$, then the beam's inner and outer diameters are 14 and 16 mm and the beam current is 1 kA. From (5) it is easy to see that the necessary critical magnetic field for beam stability is 1.1 kG. The reason for the reduction, apart from factors in (5), is due to the area being 1.67 times larger than for the solid core beam, correspondingly reducing the beam current density.

The laser gain α is approximately directly proportional to the electron transverse velocity $v_\perp$ and the factor ψ where

$$v_\perp = \Omega_w v_z / (\Omega - \gamma k_w v_z)^{[2]} \tag{6}$$

$$\psi \equiv \{1 - \Omega \gamma_z^2 v_\perp^2 / [(v_z^2 + v_\perp^2)\Omega - \gamma k_w v_z^3]\}^{1/4} \tag{7}$$

in which $\Omega_W \equiv eB_r/mC$, B_r is the wiggler field strength; and $k_W = 2\pi/\lambda_W$, λ_W is the wiggler field period. The other quantities are defined as above.

From formulae (6) and (7) we can see that when the guiding magnetic field approaches conditions of cyclotron resonance ($\Omega_{cr} = \gamma k_W v_Z$), $v_\perp$ and ψ suddenly rise and the laser gain rises. From Figure 2 this can be seen clearly. But Figure 2 also shows that when too near the cyclotron resonance point, the laser frequency f_{TE} macro-amplitude falls off and cannot again attain periodic millimeter band radiation. Moreover, at this time, the electron transverse velocity $\beta_\perp$ increases too much creating electron beam thermal instability, causing the energy dissipation of the beam to deteriorate sharply, which in turn drops the gain macro-amplitude. For this reason, we selected a design operating point at $B_0 = 10$ kG (Figure 2). At this place the corresponding laser wave length is 6.91 mm (K_a band), or $\beta_\perp = 0.211$.

Because the two aspects above are considered together, it determines that our guide magnetic field ought to be adjustable within 0∿20 kG. The magnetic field transverse covering range ought to be 1 m and above (covering the entire wiggler field).

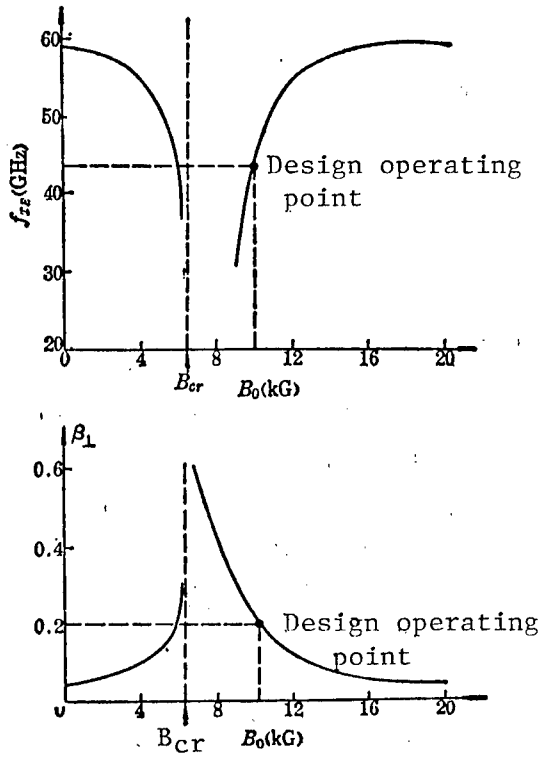

Figure 2. Functional Relationship of the Electron Transverse Velocity, $\beta_\perp$ and $TE_{//}$ Transverse Laser Coupling Frequency f_{TE} to the Guiding Magnetic Field B_0. B_{cr} is the cyclotron resonance point.

III. Test and Experimental Results

We carried out tests on a coil constructed as required according to the above needs (fabricated by the Chinese Academy of Sciences, Hefei Plasma Research Institute). Using ϕ0.24 mm enamel covered wire we constructed a small test coil with average diameter ϕ5 m and 50 turns. The measured magnetic field micro signal (dB_0/dt), after passing through integration by a freely constructed Miller integrator, was displayed on an oscilloscope. Typical wave forms were like those shown in Figure 3. One can see that the time when the maximum value was reached was 8 ms, equal to the computed results according to an LCR circuit. The measured results moving along the axis are given in Figure 4. We see from this that not only in the entire free-electron laser operating region (from the wiggler field entrance to its exit) there is everywhere a guiding magnetic field cover which is very stable (deviation < 5%), but also in the diode there is also a rather strong guiding magnetic field cover, consequently satisfying the design requirements of a magnetic field immersion type diode.[3]

Figure 5 shows the relationship between the guiding magnetic field, B_0, and the charging voltage on the capacitor in the impact current generator. The solid line and the values computed by LCR circuit theory ($B_0 = 6.06 \cdot V_{charge}$) agree very well.

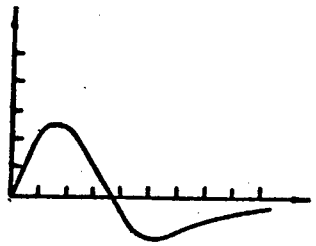

Figure 3. Measured Guiding Magnetic Field Wave Form

(Time axis 5 ms/div; vertical axis 3.6 kG/div. Conditions: Capacitor charged to 1500 V and measured on the central axial line of the guiding magnetic field coil)

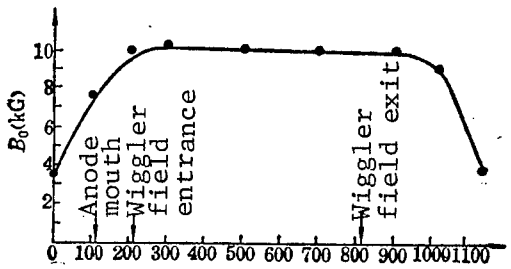

Figure 4. Measured Guiding Magnetic Field Distribution Along the Axis (Z direction)
(Capacitor voltage 1500 V; measured on the central axis of the coil)

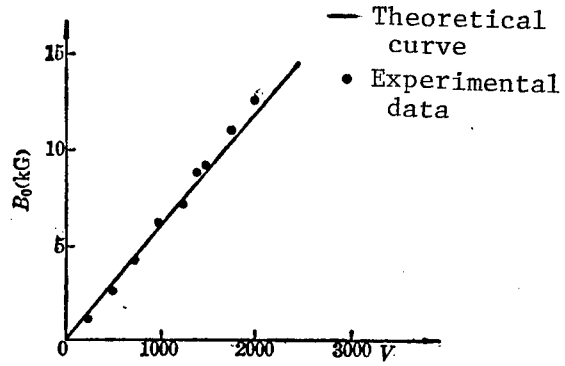

Figure 5. Relationship of the Axial Guiding Magnetic Field to the Capacitor Charging Voltage
(Measured on the central axis of the guiding magnetic field coil)

Using this guiding magnetic field coil, we obtained a highly collimated electron beam. A typical far field target photograph is shown in Figure 6. Under conditions of a 9 kG magnetic field restraint, the electron beam cross section at 1 meter maintained the entrance point dimensions (ϕ6 mm). Basically this was a 1:1 mapping of the diode exit with only isolated slight expansion of about 0.1 mm.

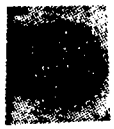

Figure 6. Solid Core Electron Beam Far Field Target Image When the Guiding Magnetic Field B_0 = 9 kG
(Conditions: diode exit inner diameter ϕ6 mm; target 1 m from diode exit. Photograph twice the original size)

These two kinds of electron beams under a guiding magnetic field matched wiggler pump both gave free electron laser output (coherent super-radiation).[1] Two sets of experimental results are shown in Figure 7. This figure clearly shows that the influence of the axial guiding magnetic field, B_0, on the output laser energy is massive. In the range B_0 = 9~10 kG (corresponding to an iron ring wiggler field strength of $B_w \simeq$ 500 G) the radiated energy was higher which tallies with the design operating points shown in Figure 2. In this range, measurements of laser wavelength by a series of high pass filters were all 8 mm (K_a band). This accords with the theoretical value given in Figure 2 (a frequency of about 44 GHz). The other operating parameters of Figure 7 are: electron beam energy 0.5 MeV, beam current 1 kA, electron beam sustain time 60 ns, annular electron beam cross section outer diameter ϕ16 mm, inner diameter ϕ14 mm; drift tube inner diameter ϕ20 mm, the iron ring wiggler had altogether 26 periods, each 22.5 mm long, for a total length of 585 mm; the radiation from gain was horn output of 13 dB, reception was from an H surface fan shaped horn; a 3 m long K_a band standard wave guide lead into a shielded chamber to measure the frequency and time spectra of the radiated pulse; and the laser energy was measured by a charcoal calorimeter.

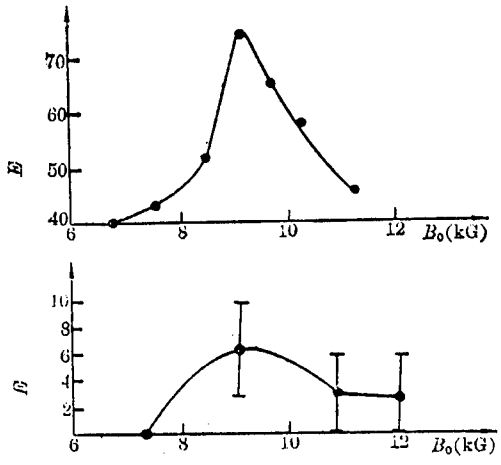

Figure 7. Effect of Guiding Magnetic Field B_0 on the Laser Output Energy
(Conditions: above, annular electron beam; below, solid core electron beam; using an iron ring wiggler pump (period 22.5 mm))

When the guiding magnetic field position is at the optimum value of 9 kG, a typical set of values from better results are obtained: energy 13 mJ, pulse half height width 25 ns, average power 0.5 MW, instantaneous electronic efficiency 0.1%, and wave length of about 8 mm (K_a band).

The guiding magnetic field coil was designed and fabricated by Shi Jiabiao, Pan Yinnian, and Wang Wei of the Chinese Academy of Sciences, Hefei Plasma Research Institute. In addition, this research was done under the guidance of Professor Wang Zhijiang. Here we offer our sincere gratitude to these individuals.

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Al-Ti CAST Ni-BASED SUPERALLOY

Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 22, No 2, 18 Apr 86 pp A93-A100

[Article by Zhu Yaoxiao [2612 3613 1366], Xu Leying [1776 2867 5391], Zhao Hong'en [6392 3163 1869], Tong Yingjie [0157 2867 2638], and Shi Changxu [1597 2490 4872] of the Institute of Metal Research, Chinese Academy of Sciences, Shenyang: "Formation of ($\gamma + \gamma'$) Eutectic and Control of σ-Phase in a High Al-Ti Cast Ni-Based Superalloy"; first paragraph is source-supplied English abstract]

[Text] Abstract: An investigation was made of the various phases, the order they are formed and their compositions in a high Al-Ti cast Ni-based superalloy under different temperatures during the process of solidification and segregation of alloying elements. The formation of ($\gamma + \gamma'$) eutectic and the control of σ phase precipitation have been discussed. During solidification of the alloy, the dendritic segregation of Al and V is almost unespied, and that of Ti, Cr and Mo are positive, with Ti being the most serious case. This may promote the formation of the segregation zone in the eutectic reaction and the enrichment of the σ phase by such elements as Cr, Mo, and Co in the residual liquid. There is therefore a tendency for the increase of the σ phase. However, the σ phase may be avoided either by adjusting the Al/Ti ratio and taking advantage of the difference of the segregation behavior of Al and Ti, or by controlling the cooling rate after casting.

Cast Ni-based superalloys have been used for 30 years in the manufacture of gas turbine blades. By using cast superalloys instead of deformation superalloys, the temperature tolerance of the blades was increased by 50°C. But in the last decade the service temperature of cast Ni-based superalloys has not been increased very much. The main reason was that the cast alloys had serious problems with segregation during solidification. The interdendritic ($\gamma + \gamma'$) eutectic promoted the segregation of the σ phase and prevented further alloying. The improvements of the alloy properties were therefore impeded, as discussed in Refs. 1-5. This paper discusses the solidification process and segregation of the alloys, the formation of the ($\gamma + \gamma'$) eutectic, and explores means to control the σ phase.

I. Experimental Methods

The melting and solidification of the metals were carried out in a small graphite crucible in a silicon-carbide tube furnace at atmospheric pressure.[6] The cast alloys were made into 10 mm diameter and 20 mm long cylinders and melted in the graphite crucible. The furnace temperature fluctuation was about ±3°C. By using the graphite crucible serious oxidation of the alloys was avoided but the carbon content was slightly increased. The carbon content remained below 0.03 percent and did not exceed the specified upper limit. The compositions of the samples, in percents of weight, before and after melting were as follows:

Element	C	Cr	Mo	Co	Al	Ti	V	B	Zr
Before	0.18	9.0	2.80	14.1	5.41	4.76	0.73	0.010	0.055
After	0.21	8.9	2.81	13.8	5.35	4.71	0.73	0.010	0.063

The melting and solidification procedures were as follows: The samples were first preheated to 1400°C, kept at that temperature for 5 minutes to ensure complete melting and homogenization of the TiC. The samples were then cooled to different temperatures, held at that temperature for 10 minutes, and finally quenched in an alkaline pickling solution. The samples were then sectioned and analyzed.

Segregation of the elements and compositions of the various phases are determined by electron microprobe and calibrated with standards. The standards were prepared by heating the same alloy to 1400°C, maintained at that temperature for 5 minutes and quenched in an alkaline pickling solution. Slices thinner than 1 mm were selected as standards. Even in such thin plates there was no guarantee that Ti did not segregate. For this reason the measurements on Ti were calibrated with pure metal and a correction was made.

For the solidification conditions that we used, we assumed that the compositional variations in the solidified solid-solution was not large and the residual liquid was completely homogenized. That is, we assumed that the composition of the residual liquid at a given temperature and the composition of the solid at the liquid-solid interface were representative of the equilibrium composition. Although the residual liquid was quenched, it appeared to be inhomogeneous microscopically. Especially when the amount of residual liquid was large, dendrites were clearly visible. We therefore used a large beam spot in the measurement of the residual liquid composition and the average of several locations were taken. Because the assumed solidification conditions may not be the actual conditions of the solidification process and there were also analysis errors in the microprobing, the conclusions derived from the experiments are necessarily semiquantitative and, in some cases, qualitative.

In the metallography of the high temperature solidified samples, the samples were electrolytically etched in an aqua regia and glycerol solution. The examination of the low temperature solidified samples, $CuSO_4$ etching was used. The relative amounts of the phases were determined by metallography.

II. Experimental Results

2.1 Formation Order of the Phases in Solidification

Table 1 summarizes the order of formation and the quantitative relationship of the various phases. As can be seen, the basic solidification process is the segregation of the Ni-based γ-solid solution in the high temperature cast superalloys because the L → γ + L' transformation persisted. Moreover, almost all the transformation was completed in the 1340°C-1290°C range. Figures 1-3 (photoplate A11) [photos not reproduced] show the metallographical structures of the alloys cast at different temperatures and containing different amounts of the γ solid solution.

Table 1. Order of Various Phases Transformation During Solidification of Alloy

Temperature, °C	Liquid, %	γ (+TiC), %	(γ+γ'), %	TiC, %	Y	High Cr-phase
1350	100					
1340	87	13				
1330	57	43		0.23		
1310	21	79		1.3		
1293	10	90		2.0		
1260	2.2	87.8		2.0	Start ppt.	
1250	1.6	97.1	1.3	2.0	trace	
1230	0.7	97.0	2.3	2.0	trace	
1210	trace	97.0	3	2.0	trace	Start ppt
1190	trace	97.0	3	2.0	trace	trace

When about half of the liquid has solidified into γ solid solution, primary TiC began to segregate out, as shown in Figure 4 (photoplate A11) [photo not reproduced]. Almost all the TiC were formed in the 1330°C-1293°C range. The segregation in the stage was mostly cubes. At lower temperatures and until the end of the solidification process, long strips of TiC continued to segregate out of the residual liquid, as shown in Figure 5 (photoplate A12) [photo not reproduced].

The L → (γ + γ') + L' eutectic reaction began at 1250°C. This reaction completed in a narrow temperature range of 1250-1230°C. Figure 6 (photoplate A12) [photo not reproduced] shows the eutectic structures formed at 1230°C. The (γ + γ') eutectics formed at high temperatures were thinner and although there were more γ' phases than the γ phase, the γ' phase was not dominating, as can be seen in Figure 7 (photoplate A12) [photo not reproduced]. The (γ + γ') eutectics formed at lower temperatures were not only thicker but were almost purely γ' phase, as shown in Figure 8 (photoplate A12) [photo not reproduced].

In the 1260-1210°C range the Y-phase (Ti_2CS) was segregated from the liquid, as shown in Figure 9 (photoplate A13) [photo not reproduced]. The segregation of the Y phase increased the local concentration of Ti, C and S and promoted the L → γ + L' transformation.

Below 1210°C, a high Cr-Mo phase segregated, as shown in Figure 10 (photoplate A13) [photo not reproduced]. The segregation of the high Cr-Mo phase changed the eutectic morphology. The Cr-Mo phase were small particles and could not be easily detected by the microprobe. Its composition is approximately as follows:

Ni	Co	Cr	Mo	Ti	Al	V
25	9	34	15	13	3	1

2.2 Composition of Phases and Distribution of Elements

Table 2 lists the compositions of the various phases formed at different temperatures and the distribution coefficient K of the elements. The data show that 1340-1260°C is the main reaction range for $L \rightarrow \gamma + L'$ and the redistribution of the elements may therefore be described by a single $K_\gamma\left(\frac{c_\gamma}{c_L}\right)$, where c_L is the equilibrium concentration of an element in the liquid and c_γ is the equilibrium concentration in the γ-solid solution. The K_γ values of the base elements Ni and Co are usually greater than 1, and values of K_γ of Cr, Mo and Ti are smaller than 1. For Ti the value is much smaller than 1; indicating that the Ti content in the γ-phase is low and then increases considerably in the residual liquid, forming the so-called branch segregation. The values of K_γ of Al and V are about 1 and these elements do not segregate very much.

Table 2. Chemical Composition, wt-%, and Distribution Coefficient, K, of Various Phases Formed at Different Temperature

Temp., °C	Phase	Ni	Co	Cr	Mo	Ti	Al	V
1340	γ	65.1	14.8	8.7	2.4	2.8	5.0	0.74
	L	63.1	12.9	8.8	2.9	4.8	5.4	0.76
	K_γ	1.03	1.15	0.99	0.83	0.58	0.92	0.96
1330	γ	64.9	14.0	8.5	2.3	3.1	4.7	0.76
	L	62.1	13.3	9.0	3.1	5.3	4.6	0.75
	K_γ	1.04	1.05	0.94	0.73	0.59	1.02	1.01
1310	γ	65.6	14.0	9.0	2.6	4.1	5.1	0.75
	L	59.9	13.2	9.2	3.7	7.1	4.8	0.75
	K_γ	1.10	1.06	0.92	0.72	0.57	1.04	1.0
1293	γ	65.4	14.1	8.9	2.5	4.7	5.2	0.66
	L	59.2	12.9	9.7	3.8	7.8	4.3	0.67
	K_γ	1.10	1.10	0.92	0.66	0.60	1.21	0.99
1260	γ	64.0	12.6	8.5	2.4	5.1	5.2	0.55
	L	56.0	12.9	10.8	3.7	7.2	3.9	0.55
	K_γ	1.14	0.98	0.79	0.65	0.73	1.33	1.0
1250	γ+γ'	67.1	12.4	6.1	1.8	7.3	5.2	0.56
	γ'	69.6	10.1	3.4	0.85	8.7	6.4	0.49
	γ	63.2	14.2	9.3	2.5	5.5	4.8	0.59
	L	49.9	14.4	12.7	5.3	7.2	3.2	0.48
	K_γ	1.27	1.99	0.76	0.47	0.77	1.5	1.21
	$K_{\gamma+\gamma'}$	1.34	0.88	0.49	0.34	1.01	1.6	1.20
1230	γ+γ'	69.9	10.1	3.8	0.94	9.3	5.7	0.47
	γ'	70.5	10.0	3.4	0.82	9.5	5.8	0.46
	γ	62.8	13.8	11.6	2.0	5.6	4.8	0.57
	L	46.9	13.0	14.6	6.8	6.6	2.6	0.53
	K_γ	1.34	1.06	0.79	0.30	0.85	1.81	1.07
	$K_{\gamma+\gamma'}$	1.50	0.78	0.26	0.14	1.4	2.2	0.9

In the 1250-1230°C region, both the $L \rightarrow \gamma + L'$ reaction and the $L \rightarrow (\gamma + \gamma') + L'$ eutectic reaction take place and there are two distribution coefficients $K_\gamma\left(\frac{c_\gamma}{c_L}\right)$ and $K_{(\gamma+\gamma')}\left(\frac{c_\gamma + c_{\gamma'}}{c_L}\right)$. According to the data in Table 2, K_γ and $K_{(\gamma+\gamma')}$ of Cr and Mo are both much smaller than 1 and the residual liquid is quickly enriched by these two elements. For Al, Ni and V, the K_γ, $K_{(\gamma+\gamma')}$ coefficients are much larger than 1 (for Al $K_{(\gamma+\gamma')}$ is as high as 2.2), and the residual liquid is greatly depleted of these elements. For Co K_γ is close to 1 and $K_{(\gamma+\gamma')}$ is less than 1; for Ti K_γ is less than 1 and and $K_{(\gamma+\gamma')}$ is close to 1. Since the effect of $K_{(\gamma+\gamma')}$ is greater than that of K_γ, the eutectic front edge of the residual liquid is somewhat enriched by Co but not depleted in Ti.

Below 1210°C the reactions are more complicated. In addition to the two reactions above, there are also segregations of Cr and Mo, causing the Cr and Mo contents in the surrounding liquid to drop noticeably.

III. Discussion

3.1 Formation of the ($\gamma + \gamma'$) Eutectic

To further explore the relationship between the L, γ, and γ' phases in the solidification process, we plot in Figure 11 the correlation between L, γ, and ($\gamma + \gamma'$) eutectic on a pseudo-three dimensional phase diagram of (Ni + Co), (Al + Ti), and (Cr + Mo) based on the data at 1260, 1250, and 1230°C listed in Table 2. The diagram shows that eutectic reactions begin at 1260°C and, as the temperature drops further, the eutectic reaction extends toward high Cr and Mo and low Al and Ti. The relative percentage of the γ and γ' phases and their compositions can also be read from the diagram. As can be seen, $\gamma:\gamma' \approx 1:1$ and the γ' phase dominates at lower (<1230°C) temperatures.

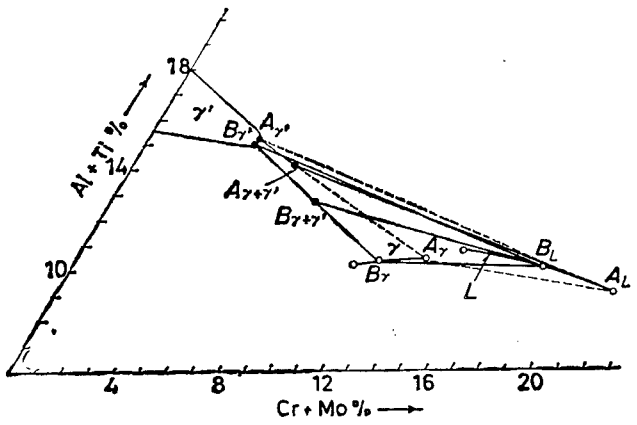

Figure 11. Correlation between L or γ and ($\gamma + \gamma'$) eutectic during solidification

Figures 12 and 13 (photoplates A13) [photos not reproduced] are two typical eutectic structures. The eutectic in Figure 12 may be divided into three parts, region I is the nucleation region, region II is the core region, and region III is the cap. Figure 13 shows the quenched structures of the ($\gamma + \gamma'$) eutectic kept for 10 minutes in the reaction temperature range of 1230°C. The picture shows a liquid phase region (fast freezing) at the leading edge of the eutectic, followed by a low γ' region. The formation of these two morphologies may be interpreted with Figure 14.

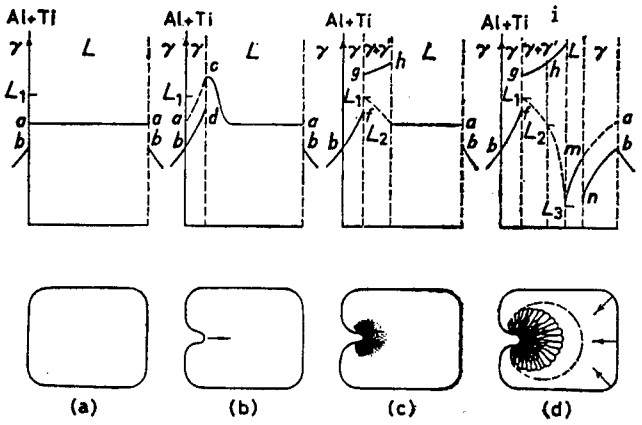

Figure 14. Schematic representation of process of ($\gamma + \gamma'$) eutectic formation (a) Liquid; (b) Beforehand stage; (c) Eutectic core formation; (d) Formation of eutectic cap and poor γ' zone

In Figure 14a, the rectangle below represents the liquid between the unsolidified branches and the rectangle is surrounded by solidified γ phase. The ordinate represents the Al + Ti content, and the abscissa represents the relative position of the solid and the liquid. To simplify the analysis, we assume that the liquid between the dendrites is uniform and has an Al + Ti content of a. This a is lower than the Al + Ti content of the L' eutectic and eutectic reactions cannot take place. The Al + Ti content of the γ phase segregated from the equilibrium liquid is b and the γ phase farther from the grain boundary has a lower Al + Ti content. These are the premises of our discussion.

Figure 14b shows the precursor of the eutectic solidification. As is well known, the solidification front generally does not propagate as a flat plane. Instead some regions grow faster than other regions and move into the liquid phase. Since Ti has a strong tendency to grow branches, it tends to enrich the liquid in front of the rapidly solidifying γ phase. In the meantime the Ni content drops and the Al + Ti concentration increases from a to c. Since the Al + Ti content of the liquid continues to rise, the content of Al + Ti in the corresponding γ solid solution rises from b to d. When the Al + Ti content in the liquid ahead of the solid/liquid interface reaches or exceeds the eutectic composition L_1, the precursor stage is completed.

Figure 14c shows the formation of the eutectic core. When the Al + Ti content of liquid c reaches or exceeds the eutectic concentration L_1, the reaction $L \rightarrow (\gamma + \gamma') + L'$ begins. At this stage the Al + Ti content required for the eutectic reaction in the liquid ahead of the interface is high and no long range diffusion is necessary, the solidification is fast and the eutectic plates are thin. As the growth continues the Cr and Mo contents in the liquid gradually increase. Judging from the trend of the eutectic composition in Figure 11, the Al + Ti content drops as the Cr and Mo content goes up. When the Al + Ti concentration drops from L_1 to L_2, and when L_2 is equal to the original content a, this stage of the reactions stops. During this stage the Al + Ti content in the $(\gamma + \gamma')$ phase is increased from g to h.

Figure 14d shows the formation of the eutectic cap. Since $(\gamma + \gamma')$ eutectic has a low content of Cr and Mo, the liquid ahead of the eutectic growth front is enriched with Cr and Mo, causing the Al + Ti content to drop rapidly from L_2 to L_3. At this time, since the Al + Ti content in the surrounding liquid is higher than L_3, Al and Ti then diffuse toward the eutectic front. The Al + Ti content in the surrounding liquid then drops and the segregation of the γ phase is accelerated. On the one hand the $L \rightarrow (\gamma + \gamma') + L'$ reaction requires Al and Ti, and on the other hand the $L \rightarrow \gamma + L'$ reaction releases Al and Ti. These two reactions complement each other. As the reactions proceed the composition of the liquid drops from L_2 to L_3, the Al + Ti content of the $(\gamma + \gamma')$ eutectic increases from h to i. The difference between i and L_3 becomes greater and greater but the Al + Ti provided by the surrounding liquid is only (m - n) and getting smaller. As a result, the liquid at the eutectic front becomes deficient of Al and Ti and the reaction slows down. In addition, the latent heat released in the freezing of the eutectic core reduces the supercooling and also causes the reaction to slow down. So, the $(\gamma + \gamma')$ cap and the γ and γ' plates become thicker and thicker. The composition of the surrounding liquid drops from a to m and the corresponding composition drops from b to n.

Due to the continuous reaction of $L \rightarrow (\gamma + \gamma') + L'$, the Cr and Mo contents in the residual liquid become higher and higher. If the Cr and Mo contents are still below the level for forming new phases, the two reactions $L \rightarrow \gamma + L'$, and $L \rightarrow (\gamma + \gamma') + L'$ proceed simultaneously until all the liquids are exhausted by the reaction. If the Cr and Mo contents in the residual liquid are so high that new phases begin to form, the segregation of the so-called high Cr-Mo phase quickly reduces the Cr and Mo contents in the residual liquid and the corresponding Al + Ti contents will increase. According to the eutectic lines in Figure 11, the eutectics formed under such conditions should be similar to the core; the γ:γ' ratio is close to 1 and the eutectic plates are thin. In Figure 10 a eutectic structure similar to the core grows in front of the cap in the vicinity of the Cr and Mo phase. This is more supporting evidence for the correctness of our presupposed formation process.

3.2 Control of the σ Phase in Alloys

There are two ways to control the σ phase: by controlling the composition and by controlling the solidification process.

The strength of the cast Ni-based superalloy comes mostly from the σ phase. High performance alloys all contain a fair amount of Al and Ti that form the σ phase. But, on the other hand, too much Al and Ti can cause a segregation of the σ phase. It is therefore an important consideration to maintain a proper amount of Al and Ti in the design of the alloy. Although both Al and Ti strengthen the alloy, they behave differently in terms of segregation, and they affect the σ phase formation in different ways. Ti has serious dendritic segregation; it promotes eutectic reactions and increases the segregation of Mo and Cr. Ti therefore favors the formation of the σ phase. Al basically does not have dendritic segregation and does not promote σ phase. The formation of the σ phase can therefore be controlled by increasing the Al:Ti ratio. If only the Ti content is reduced, the high temperature strength will be severely compromised. The Al:Ti ratio cannot be too large either; otherwise there will be segregation of the NiAl phase, which is even more detrimental to the performance. By adjusting the Al:Ti ratio, we have developed a new alloy that retained all the high temperature strength and does not have σ phase.

In the investigation of the segregation in the eutectic reaction zone, we found that the formation of the σ phase can be suppressed by speeding up the solidification and diffusing the eutectic structures. This is because of the following reasons. First, a reduced interdendritic spacing means a smaller volume for eutectic segregation. Second, a steeper concentration of Al and Ti in the liquid ahead of the solid-liquid interface in Figure 14b causes a smaller eutectic core and makes the formation of the cap more difficult. Also, the formation of the cap is a long range diffusion process, a rapid solidification prohibits the cap formation. When there is no cap, the Mo, Cr and Co segregation zone will be very small. This greatly reduces the segregation and eliminates the conditions for the σ phase.

This was also verified experimentally. Parts cast in a thin mold do not have very high performance because the solidification rate is low in thin mold casting and there are a large amount of eutectic clusters. When the mold is buried in a sandbox, the heat capacity of the pouring system and the solidification rate are increased and the performance of the resulting parts is improved. In addition, the solidification rate can also be increased by lowering the pouring temperature and the temperature of the mold.

IV. Conclusion

1. In the solidification process Al and V do not have dendritic segregation, whereas Ti, Cr and Mo do. Segregation of Ti is the most serious.

2. The serious segregation of Ti promotes the formation of a eutectic segregation zone. This zone, enriched with Cr, Mo and Co, tends to cause σ phase.

3. The segregation of the σ phase may be avoided by properly controlling the Al/Ti ratio and the solidification rate after casting.

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BEHAVIOR OF Hf IN SOLIDIFICATION OF CAST Ni-BASE SUPERALLOYS

Beijing JINSHU XUEBAO [ACTA METALLURGICA SINICA] in Chinese Vol 22, No 2, 18 Apr 86 pp A119-A124

[Article by Zheng Yunrong [6774 6663 2837], Institute of Aeronautical Materials, Beijing: "Behavior of Hf in Solidification of Cast Ni-Base Superalloy"; first draft received 21 September 1984, final draft received 27 March 1985; first paragraph is source-supplied English abstract]

[Text] Abstract: Results of quantitative metallography, SEM, EDAX and EMPA studies of Hf on the solidification of cast Ni-base superalloys are presented. The Hf is found to lower the liquidus temperature of the superalloys and causes the final solidification temperature to drop to 1130°C. The Hf narrows the temperature difference between the solidus and the liquid temperature at which the interdendritic capillary feeding action is lost. It also decreases the liquid content necessary for linking the interdendritic pools in the late stage of the solidification. The Hf-rich melts have superior fluidity, wettability and skin effect. These factors contribute to the improved castibility of the Hf-containing superalloys. The Hf is not found in the dendritic arms of the superalloys, but is extremely concentrated in the interdendritic zones and usually exists in the form of Hf-rich phases. The Hf content in the primary Hf-rich phases may be arranged in decreasing order of $MC_{(2)}$, $(Hf, Ti)_2SC$, Ni_5Hf, $MC_{(1)}$ and eutectic γ'. The Hf may depress the formation temperature of the primary phases. The solidification temperatures of all Hf-rich phases are lower than 1250°C. These primary phases may precipitate from the molten pools with a Hf concentration over 13 wt-% at the late solidification stage and may be eutectic in nature.

In our previous studies of the effects of Hf in superalloys[1-3], we found that Hf broadened the range of solidification[4]. Alloys with a broad solidification range usually have poorer castibility, which seems to contradict the recent findings of the superior castibility of alloys containing Hf[5,6]. The purpose of this paper is to investigate the effects of Hf in the solidification of superalloys.

I. Experimental Materials and Methods

The chemical compositions of the experimental materials (in wt-%) are listed below.

	Co	Cr	Al	Ti	W	Mo	Nb	Hf	C	B	Zr	S	Ni
K5	9.80	9.63	5.67	2.30	4.73	3.88	—	—	0.17	0.026	0.096	0.002	balance
K5H	9.46	9.46	5.65	2.33	4.79	3.84	—	1.80	0.15	0.022	—	0.002	balance
K19H	11.20	4.53	5.64	1.13	9.65	1.00	2.03	1.70	0.10	0.106	—	0.09	balance

In sample K19H we added 0.09%S on purpose to study the internation of Hf and S.

The experimental samples were inserted into holes drilled in graphite blocks and surrounded by silicon gel and carborundum fillings. After drying the samples were put in a high temperature furnace and heated to 1370°C and held for 15 minutes until the samples were thoroughly melted. The samples were cooled to different temperatures at a rate of about 10°C/min. After 15 minutes, the samples were quenched in water. The temperatures used were in the range of 1100-1350°C, the interval was 20°C and, for temperature sensitive phases, the interval was 5°C.

The 5 mm thick K5H sample was melted with a tungsten tip argon arc to observe the solidification of a Hf-rich melt.

The solidified samples were analyzed with metallography, quantitative metallography, SEM, EDAX, and EMPA.

II. Experimental Result

2.1 Distribution of Hf in Cast Alloys

The dendrite arms of the cast alloys do not contain Hf. All the Hf were distributed in the narrow interdendritic zones in the form of Hf-rich phases of $MC_{(2)}$, $(Hf, Ti)_2SC$, Ni_5Hf, $MC_{(1)}$, and eutectic γ', in decreasing order of Hf content. The Hf contents in the various phases of the K5H sample were measured with an electron microprobe and the average values (in weight percents) were found to be 60.6 in $MC_{(2)}$, 49.9 in $(Hf, Ti)_2SC$, 30.3 in Ni_5Hf, 9.7 in $MC_{(1)}$, 6.4 in eutectic γ', 0.61 in interdendritic region, and 0 percent in dendrite arms. The measurements in $(Hf, Ti)_2SC$ were made on the K19H alloy sample.

The Hf contents in the various phases varied greatly and the Hf concentration in the same phase also varied noticeably. The fluctuations in $MC_{(1)}$ carbide and γ' were particularly large. The Hf content in $MC_{(1)}$ varied between 3 and 20 percent by weight. The secondary γ' in the dendrite arms did not contain Hf and the average Hf content was 6.4 wt-% in eutectic γ'. Even in the same grain of eutectic γ', the Hf content was 30 percent higher at the outer edges than at the center.

2.2 Variations of the Solid/Liquid Ratio in Isothermal Solidification

In K5H alloy small amounts of γ dendrites began to form at 1345°C. As the temperature dropped the dendrites grew rapidly and a skeleton was formed at 1310°C. At 1250°C it was still 7 percent liquid by volume and the liquids

were still connected, see Figure 1a (photoplate A16) [photo not reproduced]. At high magnification capillaries connecting the microscopic liquid pools were visible (Figure 1b). At 1180°C, 0.5 percent by volume liquid remained and this portion of the liquid completely solidified into Ni_5Hf at 1130°C.

Solidification began at 1355°C in the Hf-free K5 alloy, but the liquid pools quickly became disconnected at 1310°C when the liquid content was 10 percent by volume. The alloy completely solidified at 1180°C. The liquid content in these two alloys were carefully observed at different (T_L - T) and the results are shown in Figure 2.

As can be seen, the alloy containing Hf maintained a high level of liquid over a wide temperature range in the late stages of solidification, but the amount of liquid required to maintain connections between the pools was at minimum 7 percent by volume.

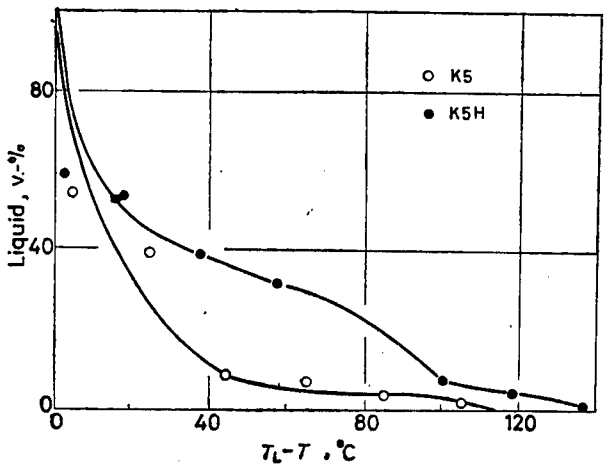

Figure 2. Relationship between liquid content and temperature of liquidus, T_L, minus isothermal, T, for K5 and K5H

2.3 Temperature Dependence of Hf Content in the Melt Pool and Growth of the Hf-Rich Phase

The Hf concentrations in the liquid pool in samples solidified isothermally at different temperatures were measured with a combination of EDAX and EMPA. For samples with more than 20 percent liquid by volume, EDAX was used in the analysis of the gross composition of the liquid pool before quenching. For samples with less liquid, EMPA was used for spot analysis. The spot size was 10 micrometer and the average of 10 measurements was taken. The results are shown in Figure 3. As can be seen, the Hf content of the interdendritic liquid increased rapidly below 1290°C. In the 1250°C-1230°C range the Hf content of the liquid poor decreased slightly, perhaps because of the precipitation of Hf-rich $MC_{(2)}$.

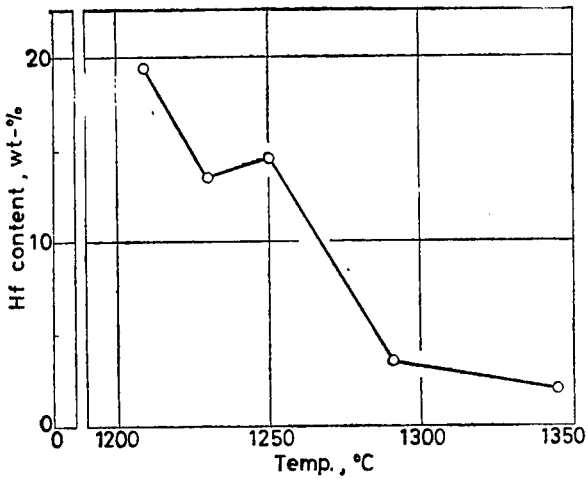

Figure 3. Relationship between Hf content of melts and temperature of isothermal solidification for alloy K5

The order of precipitation of the primary K5 and K5H alloys was determined by metallography of isothermally solidified samples. The results are shown in Figure 4. It shows that the Hf decreased the liquidus of the alloy and lowered the final solidification temperature to 1130°C. Also, the precipitation temperature of the primary phase in alloys containing Hf was even lower. Compared to Hf-free alloys, the M_3B_2 precipitation temperature was lowered by 20°C. The precipitation temperature of $MC_{(1)}$ did not change very much, but the amount of precipitation at a given temperature was far less than the Hf-alloy. That is, the peak precipitation of the primary phase in the Hf alloy was even lower and precipitation took place over a wider temperature range. This behavior was also confirmed by differential thermal analysis.

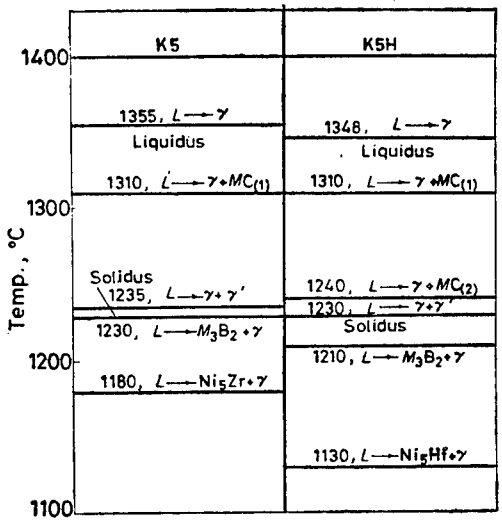

Figure 4. Order of solidification of alloy K5 and K5H

Another feature of the alloy containing Hf was that, in addition to $MC_{(1)}$, other Hf-rich phases precipitated out at a Hf concentration higher than 13 percent by weight and at temperatures less than 1250°C. Figure 5 (photoplate A16) [photo not reproduced] shows the $MC_{(2)}$ phase formed at 1230°C 15 minute isotherm. It was often attached to $MC_{(1)}$ formed earlier and caused an eutectic of $MC_{(1)}$ and $MC_{(2)}$.

In samples solidified at lower temperatures co-growth of $MC_{(2)}$, M_3B_2 and Ni_5Hf was frequently found, see Figure 6 (photoplate A16) [photo not reproduced]. The Ni_5Hf phase showed eutectic morphology but $MC_{(2)}$ and M_3B_2 were in lumps.

EMPA analysis further confirmed the eutectic growth of $MC_{(2)}$ and M_3B_2. The composition charts in Figure 7 (photoplate A17) [photo not reproduced] show that $MC_{(2)}$ is rich in Hf and contains small amounts of W and Ti. The M_3B_2 phase is rich in Mo, Cr, and W. Quantitative analysis verified that, even though the two phases were eutectic, they contained widely different amounts of Hf. $MC_{(2)}$ contained as much as 60 percent by weight Hf but M_3B_2 did not contain Hf.

Because of the small content of the $(Hf, Ti)_2SC$ phase in the K5H alloy, its precipitation temperature could not be accurately determined. Tests using the K19H alloy with 0.09 percent S showed that $(Hf, Ti)_2SC$ began to precipitate at 1240°C and completely precipitated at 1180°C. Samples isothermally solidified and quenched in this temperature range often had flakes of $(Hf, Ti)_2SC$, indicating that both Hf and S precipitated in the liquid pool that solidified last and combined to form sulfides.

2.4 Skin Effect of Hf-Rich Melts

In the argon arc weld of a K5H plate with a tungsten tip, a thin Hf-rich layer was found near the weld and the heat affected zone. The Hf content of this layer was three times higher than the average Hf content in the alloy. Metallographical analysis showed that the microstructure of the Hf-rich layer, a typical Ni-Hf eutectic structure, was different from those within the weld, as shown in Figure 8 (photoplate A18) [photo not reproduced].

The Hf-rich layer was formed in the late stage of the solidification when the interdendritic liquids were connected. The Hf-rich melt effused outwards along the capillaries between the dendrite arms and formed a Hf-rich film at the surface. The surface of the solidified sample showed signs of liquids effusing out of a small hole and covering the surface, see Figure 9 (photoplate A18) [photo not reproduced].

The skin melt was analyzed with EMPA and its composition was compared with that within and between the dendrite arms. The results are listed in Table 1. As can be seen, the composition of the skin melt is closer to that of the interdendritic composition. This shows that the skin melt was formed in the late stage of the solidification and flowed to the surface.

Table 1. Composition of Skin Melts, Dendrite and Interdendrite in Alloy K5H, wt-%

Location	Cr	Al	Ni	Ti	Mo	W	Hf	Co
Skin melt	9.04	4.63	58.45	3.93	3.85	4.89	6.55	8.84
Interdendrite	9.83	5.18	62.22	3.38	4.29	3.39	3.06	8.65
Dendrite	9.37	5.09	64.50	1.90	3.59	5.84	0.00	9.71

Sectioning of ingots containing Hf further revealed that the blow hole surfaces in ingots with more than 1.5 percent Hf by weight often had a bronze-colored surface layer. Electron microprobe analysis showed that the Hf content of the layer was between 3 and 7 percent by weight. Cast parts containing Hf were also bronze in color, this color difference may be used in the qualitative sorting of parts with and without Hf.

Unlike the weld seam, the Hf-rich surface of the cast parts contained oxides of Hf rather than eutectic Ni-Hf. Particles containing oxygen and more than 70 percent Hf by weight were ubiquitous on the surface. They may be HfO_2 particles formed in the interaction of the skin melt and the mold.

III. Results and Discussion

Although Hf lowered the final solidification temperature of the alloy, the interdendritic liquids remained well-connected before the precipitation of the eutectic γ'. Moreover, the Hf-rich melt produced in the late stages of the solidification had good fluidity and could easily flow through the narrow channels between the dendrites. Since the liquid pools were connected by narrow channels, the amount of liquid needed to connect the pools was kept to a minimum of 7 percent by volume, and the amount of liquids in isolated pools was reduced. The Hf-rich melts had superior fluidity, wettability and skin effect, these are the factors in increasing the castibility of the superalloys containing Hf.

Hf modified the solidification behavior of the superalloys by changing the skeleton structure of MC and M_3B_2 to lump-like. Because the Hf-rich phases solidified last, the Hf-rich particles did not serve as nucleation centers; instead, Hf lowered the solidification temperature of the melt and changed the precipitation sequence of the primary phases. As a result, the original eutectic phases could crystallize freely in the melt or attach to phases formed earlier. It is generally believed that free crystallization phases have better geometric symmetry. Also, the melts that solidified last had a high level of Hf, which can fully combine with the sulphur precipitated in the pool to form a $(Hf, Ti)_2SC$ phase with a higher melting point than nickel sulfide and eliminated the adverse effects of the sulphur. This "purification" effect helped to enhance the connection strength of the dendrites and may be one of the important reasons in improving the mechanical performance of cast superalloys.

The skin effect of the Hf-rich melt is a physical metallurgical phenomenon with practical significance. In the solidification of the weld seam, the

skin effect may play a role of self-welding to heal cracks already formed. The noticeable reduction of cracks in the welding of Hf-containing alloys may be related to this property of Hf-rich melts. But on the other hand, the skin effect also has certain disadvantages in mold casting. The highly active Hf-rich skin film may react with Al_2O_3 in the mold and form HfO_2. This reaction not only depletes the Hf in the alloy and causes different Hf contents in the top and bottom parts of the directionally solidified billet, the high density HfO_2 also brings difficulties in the recycle of the material and its removal may require a filtering process of the molten metal.

IV. Conclusion

1. The dendrite arms of cast superalloys do not contain Hf. Hf exists in the form of Hf-rich phases. The primary phases may be ordered as follows in decreasing order of Hf content: $MC_{(2)}$, $(Hf, Ti)_2SC$, Ni_5Hf, $MC_{(1)}$, and eutectic γ'.

2. Hf causes the final solidification temperature of the superalloy to drop to 1130°C. It lowered the temperature for interdendritic capillary feeding by 60°C and reduces the liquid volume for keeping the interdendritic liquid pools connected to 7 percent by volume.

3. All the Hf-rich phases are late-solidifying phases. The precipitate out of liquid pools with Hf concentrations greater than 13 percent by weight at temperatures below 1250°C.

4. The superior fluidity and skin effect of the Hf-containing melts are two of the reasons for the superior castibility of the Hf-containing alloys.

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ENVIRONMENTAL PROTECTION PLANS DETAILED

Beijing HUANJIANG BAOHU [ENVIRONMENTAL PROTECTION] in Chinese No 11, Nov 86 pp 2-3; 32

[Article by Li Jinjing [2621 6855 2533]: "Popularization of an Important Strategic Guiding Thought: Some Reflections on Participating in the National Overall Land Plan Outline Symposium"]

[Excerpts] Recently, the State Planning Commission convened a National Overall Land Plan Outline Symposium. The keynote report given by Comrade Song Ping [1345 1627], state councilor and chairman of the National Planning Commission, and the conference documents and the speeches by many representatives all emphasized: the aim of formulating a national overall Land Plan Outline is to correctly coordinate and handle the relationship between economic development and population, resources, and the environment.

Looking at the situation domestically, since 1949, China's socialist construction has made enormous achievements. But for a long time, economic construction has suffered several major setbacks, and in addition to factors in political and work guidance, there is also a large problem with having a low regard for correctly coordinating and handling the interrelations of economic development and population, resources and the invironment, with lacking such comprehensive plans as population control, land management, resource development, and environmental protection, and there is definite recklessness leading to violations of ecological laws and economic laws. This is an important lesson in China's socialist modernization. Even now, the aftereffects naturally disturb us and it is urgent for us to resolve them. For example, errors in population control have crated an excessive expansion of China's population, and population has become a restrictive factor on economic development and improvement of the people's standard of living; mistakes of the "Great Leap Forward" not only led the economy into decline but also inflicted damage on the ecology and resources; the several changes in handling the relationship between seacoast and the interior have caused problems in the distribution of productive forces and distribution of resources. Overlooking rational development and utilization of rivers, lakes and underground water resources have created a serious shortage of water in the north, and there have been droughts in some cities; we have one-sidedly emphasized that "food is the program," blindly opened new land, destroyed fields and forests to plant grain, randomly cut and denuded forests, overgrazed in grasslands, destroyed plant cover, and lowered the coverage rate.

Desertification of the land is severe, ecological and environmental deterioration, drought and waterlogging damage has proliferated, and the threat of floods has increased. By considering only production and the value of production and ignoring enviornmental protection, we have created severe environmental pollution. These facts fully prove that the damage suffered by China's land resources and ecological environment is rather severe and comprehensive development management and enviornmental protection work urgently need to be strengthened. This is a necessary demand of China's socialist modernization entering a new historical period.

Since the Third Plenum of the 11th CPC Central Committee, the work emphasis of our party and state has shifted to economic construction. The national economy has greatly developed and the greatness of the accomplishments has been the focus of the world's attention. To ensure the even smoother implementation of China's socialist modernization, and the more continued, stable and coordinated development of the national economy, the party and state are effectively carrying out reform of the economic system and corresponding political system. This great pioneering undertaking must accelerate the pace of China's revitalization, strengthening of the government and enrichment of the people. At the same time, we cannot overlook the difficulties we are facing.

The environmental issue can be divided into two classes: one is environmental pollution, and the other is ecological damage. The former primarily occurs in developed countreis, and the latter primarily occurs in developing countries. China is a developing country, but these two classes of environmental issues both exist here and are also both very serious, and some are even getting worse. The ecological environment and land resources such as water, soil, and trees which are the material basis of mankind's existence are also of an irreplaceable nature, once they are damaged or lost, there are no substitutes nor can they be imported. Thus this is related to the rise and fall of the peoples and the nation and cannot be overlooked.

Since the Third Plenum of the 11th CPC Central Committee, the party and state have given special concern and consideration to environmental protection and comprehensive land development and management work. In terms of environmental protection, prevention and control of environmental pollution, protecting the ecological balance, promoting economic development, and creating wealth for later generations have been set as an important and basic policy of China, and a series of laws and regulations, such as "Environmental Protection Law" and "Forest Law" have been formulated, and economic and administrative management techniques have been strengthened. In terms of comprehensive land development and management, the CPC Central Committee and the State Council issued another directive demanding the establishment of a special management agency, legislation, and planning and demand that regions and departments coordinate closely to carry out this major undertaking. According to the CPC Central Committee and State Council directive, for several years the State Planning Commission and its Land Management Bureau have done a great deal of work, and on the basis of organizing specialists from various areas for thorough surveys and research and repeated verification, and having gone through several drafts, have drawn up a National Overall Land Plan Outline (Draft). Beginning with analyzing the characteristics, advantages and problems of land resources, this plan sketches a basic blueprint of land development and management and construction

distribution, puts forth important development and management demands, clarifies key development directions in development areas, and formulates important policies and measures for implementing the plan. Concretely, it includes the following four items: First, proceeding from rational development and utilization of land resources and society's material technological base, to arrange for the overall distribution of productive forces as best as possible; second, proceeding from maintaining and creating a suitable ecological enviornment, to propose principles, missions, demands and major management projects for the prevention and treatment of natural calamities and pollution of the "three wastes"; three, proceeding from exploiting the regional overall superiority, to clarify the directions, goals, and steps for regional development and construction; four, defining such land development and management planning indicators as area of land to be kept in cultivation, area of land for soil and water conservation, area for prevention and treatment of desertified land, area for saline-alkali land control, forest cover rate, balance of water resources supply and demand, flood prevention standards for large rivers, and level of urbanization, and proposed measures to implement these indicators. Although this outline is directional and only a rough outline, and although there are still some defects and even errors, nevertheless it is the embryo of the first overall plan for comprehensive land development and management formulated in China's history and provides an excellent basis for discussion. It is entirely believable that after conscientious discussion by scholars, specialists, and responsible comrades from regions and departments, and pooling the wisdom of the masses, it can certainly be revised and made even better. Such an overall plan for comprehensive land development and management serves the overall goals and overall mission of China's socialist modernization, is an important part of the long-range plans for China's national economy and social development, and complements long-range environmental protection plans. Once formally approved and promulgated by the state, it will become a programmatic document and a milestone. This is because under its direction China's land development work might overcome recklessness and intensify self-consciousness; China's ecological environment might gradually turn from continuous deterioration to gradual recovery and improvement; the relationship between Chinese economic development and population, resources and the environment might be better coordinated. The smooth advance and development of socialist modernization has rather reliable assurances of such a material foundation of resources and the environment.

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ENVIRONMENTAL QUALITY

SHANGHAI POLLUTION LESS SEVERE

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[Text] Shanghai, 3 Apr (XINHUA)--Residents of Shanghai, China's largest industrial city, can now clearly see the TV tower standing in the center of the city as the city's chronic black smog has disappeared.

A 12-meter-wide cloud containing industrial sulphide and iron dust has surrounded the TV tower, 209 meters high, for more than ten years, a local environmental protection expert noted.

With a population of 12 million, Shanghai has more than 8,000 factories, he said.

The main sources of air pollution are steel plants, power plants and chemical factories.

As a result, out of 700,000 residents living in the Hetian industrial region, which has 14 chemical factories, there were 10,000 sufferers of lung diseases before 1978.

Many residents wrote letters to the municipal bureau of environmental protection, complaining about the pollution, said an official of the bureau, which received 2,000 to 3,000 letters a year in the past, but only 50 so far this year.

The official said that the city government has earmarked 100 million yuan for environmental protection over the past seven years.

Other pollution sources, however, are the residents themselves, he said, because more than 860,000 households still use coal as fuel.

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